

# CARBON CAPTURE AND SEQUESTRATION LEGISLATION

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## HEARING BEFORE THE COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE ONE HUNDRED TWELFTH CONGRESS FIRST SESSION TO RECEIVE TESTIMONY ON CARBON CAPTURE AND SEQUESTRATION LEGISLATION, INCLUDING S. 699 AND S. 757

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## **CARBON CAPTURE AND SEQUESTRATION LEGISLATION**

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**THURSDAY, MAY 12, 2011**

U.S. SENATE,  
COMMITTEE ON ENERGY AND NATURAL RESOURCES,  
*Washington, DC.*

The committee met, pursuant to notice, at 9:03 a.m. in room SD-366, Dirksen Senate Office Building, Hon. Jeff Bingaman, chairman, presiding.

### **OPENING STATEMENT OF HON. JEFF BINGAMAN, U.S. SENATOR FROM NEW MEXICO**

The CHAIRMAN. I'd like to welcome everyone here and thank the witnesses for coming to testify this morning.

This is a hearing on two bills, S. 699 and S. 757. These 2 bills both focus on important aspects of carbon capture and storage that Senator Barrasso and I have been working on together in this Congress but also in the previous Congress.

S. 699 focuses on creating a long term liability program that would incentivize large scale early mover deployment of integrated geologic carbon capture and storage.

S. 757 is a bill that focuses on creating a technology prize for the successful demonstration of carbon dioxide capture from dilute sources such as the air. The topic of reducing greenhouse gases, particularly carbon dioxide emissions is a great concern to me and to other members of this committee. Carbon capture and geologic storage holds promise as a measure that can be used to mitigate a changing global climate while still allowing the use of fossil fuels at electric generating plants and industrial facilities such as steel manufacturing and cement plants. With discussion centered on coal use in a carbon constrained world integrated carbon capture and storage systems may represent the most immediate solution for continued use of coal and other carbon intensive fuels while not contributing further to carbon dioxide emissions and global warming.

These two bills were introduced in the 111th Congress. We successfully passed them out of committee with a strong bipartisan vote. We're here today to receive testimony and update the record in the 112th Congress.

I'd like to welcome our panel of experts before hearing from them. Let me turn to Senator Barrasso for any opening comments he has.

**STATEMENT OF HON. JOHN BARRASSO, U.S. SENATOR  
FROM WYOMING**

Senator BARRASSO. Thank you very much, Mr. Chairman. I want to thank you personally for your leadership on carbon capture and sequestration. I'm privileged to be an original co-sponsor of your Carbon Capture and Sequestration Liability bill.

Uncertainty over liability is a major impediment to carbon capture and sequestration deployment. This bill will address that question for the first ten projects. I believe it's a very important step.

When it comes to carbon sequestration issues the State of Wyoming is a national leader. The Wyoming legislature enacted laws creating the legal framework for carbon sequestration. The Wyoming State Geological Survey has identified and characterized sequestration sites within the State.

The University of Wyoming is partnering with the private sector to develop innovative technologies. Wyoming has a long history as an energy producing State. We can use this knowledge and experience to make carbon sequestration a reality. There are steps, though, that the Federal Government must take first. That includes addressing the issue of liability.

My direct air capture bill, the Carbon Dioxide Capture Technology Act is also on today's agenda. I'd like to thank you, Mr. Chairman, for partnering with me on this legislation. This bill takes a fresh approach to the issue of excess carbon dioxide. It would create a prize system for developing technology that directly removes CO<sub>2</sub> from the atmosphere.

An article 2009 in the Economist, lays out the issue clearly. Some researchers think there might be a simpler way to reduce the level of CO<sub>2</sub> in the atmosphere, it says. To build air capture machines that as their name suggests grab it from the air.

It goes on to say in some respects this is a more ambitious version of the carbon capture and sequestration technology. Air capture has the further advantage that it can be done anywhere, not just in places where carbon dioxide is being emitted such as power stations. So, Mr. Chairman, rather than focusing on solutions that impose costly regulations or taxes, this bill focuses solely on innovation.

So I look forward to hearing the analysis and suggestions from today's panel. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you. I know Senator Franken has some other hearings he's going to have to leave and go to at some point. So let me just see if he had anything he wanted to say at this early point.

Senator FRANKEN. Not at this moment. This would be—if we can do this it'd be a really helpful way to address climate change. So, I'm looking forward to the testimony.

Thank you. Thank all the witnesses for being here today.

The CHAIRMAN. Alright. Why don't we start? Let me introduce all of our witnesses.

Mr. Scott Klara is the Deputy Director of the National Energy Technology Laboratory in Pittsburgh. Thank you for being here.

Miss Sallie Greenberg is the Assistant Directory with the Advanced Energy Technology Initiative at Illinois State Geologic Survey. Thank you for being here.

Mr. Matt Watson is a Senior Energy Policy Manager with the Environmental Defense Fund. Thank you for coming.

Ms. Chiara Trabucchi, is that reasonably accurate? Thank you for being here. She is the Principal and Chief Financial Officer with the Industrial Economics Incorporated in Cambridge, Massachusetts.

Alright. Please let's just have you go in that order, if you would. Give us 5 minutes or so of the main points we need to understand about your views on these 2 pieces of legislation.

Mr. Klara.

**STATEMENT OF SCOTT KLARA, DEPUTY LABORATORY DIRECTOR, NATIONAL ENERGY TECHNOLOGY LABORATORY, DEPARTMENT OF ENERGY**

Mr. KLARA. Thank you, Chairman Bingaman, Ranking Member Barrasso and other members of the committee. I appreciate the opportunity to discuss the department's activities to promote the development of carbon capture and storage technologies. I will refer to this as CCS throughout my remarks.

My testimony will provide an overview of the department's research efforts in developing CCS technologies. The administration is still reviewing the specifics of these 2 bills and doesn't have a formal position at this time.

Before I discuss the department's clean coal research program or CCS activities, I will briefly review the conclusions from the Interagency Task Force on CCS. In August 2010 the final report from the Task Force was issued summarizing the administration's efforts to develop and deploy CCS technologies and the proposed plans to overcome the barriers for widescale deployment in 10 years with a goal of bringing at least 5 to 10 commercial demonstrations online by 2016.

The report is the collective work of 14 executive departments and Federal agencies which were tasked with developing a comprehensive and coordinated Federal strategy to speed the commercial development and deployment of these task force—or of these technologies. The Task Force concluded while there are no insurmountable technical, legal, institutional, regulatory or other barriers that prevent CCS from playing a key role in greenhouse gas reduction, early CCS projects, as many of you know, face economic challenges related to climate policy uncertainty, first of a kind technology risk and the current high cost associated with the technologies.

DOE continues to play a leadership role in the development of these technologies. The programs that we run are administered by the Office of Fossil Energy and implemented by the National Energy Technology Laboratory. The coal program, in partnership with the private sector, is focusing on 2 key aspects in development: maximizing efficiency and environmental performance while minimizing the costs of these technologies.

In recent years we've been restructured around the CCS mission and focusing on a 2-prong approach.

The first is the capture and storing of the greenhouse gases.

But second in conjunction with that an important aspect is improving the efficiency of fossil energy systems. As many of you may be aware, one of the key issues of carbon capture is these big efficiency penalty hits.

The first strategy aims at concerns to reduce the greenhouse gas emissions from these fossil fuel systems.

The second is to improve these fuel to energy efficiency, the system, thus reducing emissions, water use, carbon dioxide on a per unit energy basis.

Collectively these 2 strategies comprise the program's approach in coming up with technologies for the future. The program is addressing these technical challenges through research on cost reduction for capture, monitoring verification and accounting technologies to ensure permanent storage, permitting issues and the development of advanced energy systems with these high efficiency gains. A key aspect of the research is focusing on developing options to dramatically lower the cost of carbon capture. This research is categorized into 3 pathways: Postcombustion, precombustion, oxycombustion.

These pathways provide technology diversity that will allow for CCS integration and nearly all current and future fossil energy systems. This research is exploring a wide range of approaches such as membranes, oxy combustion concepts, sorbents and gas liquid scrubbing.

Another key initiative is the Regional Carbon Sequestration Partnerships. The Partnerships are designed to form of network of capability, knowledge and infrastructure to enable carbon sequestration technology to play a major role in a national strategy to mitigate greenhouse gas emissions. These partnerships are comprised of State agencies, universities and private companies that represent more than 400 unique organizations in 43 States and 4 Canadian provinces. They also encompass regions that encompass 97 percent of coal fired CO<sub>2</sub> emissions, 97 percent of industrial CO<sub>2</sub> emissions, 96 percent of land mass and essentially all of the geologic storage sites that could potentially be available for carbon sequestration.

The success of this program and the technologies that are emerging will ultimately be judged by the extent to which they get deployed in domestic and international marketplaces. Both technical and financial challenges associated with these high risk technologies must be overcome. To facilitate commercialization of integrated CCS systems, the Department is pursuing many commercial scale demonstrations to help industry understand and overcome startup issues, component integration and gaining early learning commercial experience necessary to reduce risk.

CCS and related coal technologies, as you're aware, can play a critical role in the future of mitigating CO<sub>2</sub> emissions. The Department's research programs are a vital step to achieving the readiness of these technologies for these future deployments. I thank this committee and its members for allowing me the opportunity to provide remarks today. I look forward to our discussion.

Thank you.

[The prepared statement of Mr. Klara follows:]



PREPARED STATEMENT OF SCOTT KLARA, DEPUTY LABORATORY DIRECTOR, NATIONAL ENERGY TECHNOLOGY LABORATORY, DEPARTMENT OF ENERGY

Thank you Chairman Bingaman, Ranking Member Barrasso, and members of the Committee; I appreciate the opportunity to discuss the Department of Energy's activities to promote the development of carbon capture and storage (CCS) technologies.

My testimony will provide an overview of the Department of Energy's (DOE) research efforts in developing CCS technologies. The Administration is still reviewing S. 699 and S. 757 and does not have a position on either bill at this time.

INTERAGENCY TASK FORCE ON CARBON CAPTURE AND STORAGE

Before I discuss the Department's Clean Coal Research Program, I will briefly review the conclusions from the Interagency Task Force on CCS. In August 2010, the final report from the Task Force was issued summarizing the Administration's efforts to develop and deploy CCS technologies, and proposed a plan to overcome the barriers to the widespread, cost-effective deployment of CCS within ten years, with a goal of bringing five to ten commercial demonstration projects online by 2016. This report is the collective work of 14 executive departments and federal agencies, which were tasked with developing a comprehensive and coordinated Federal strategy to speed the commercial development and deployment of clean coal technologies. The task force concluded that while there are no insurmountable technological, legal, institutional, regulatory or other barriers that prevent CCS from playing a role in reducing GHG emissions, early CCS projects face economic challenges related to climate policy uncertainty, first-of-a-kind technology risks, and the current high cost of CCS relative to other technologies.

CLEAN COAL RESEARCH PROGRAM

DOE continues to play a leadership role in the development of clean coal technologies with a focus on CCS. The Clean Coal Research Program—administered by DOE's Office of Fossil Energy and implemented by the National Energy Technology Laboratory—is designed to enhance our energy security and reduce environmental concerns over the future use of coal by developing a portfolio of revolutionary clean coal technologies. The Program is well positioned to help overcome the technical challenges associated with the development of clean coal technologies.

The Clean Coal Program, in partnership with the private sector, is focused on maximizing efficiency and environmental performance, while minimizing the costs of these new technologies. In recent years, the Program has been restructured to focus on clean coal technologies with CCS. The Program pursues the following two major strategies:

- 1) capturing and storing greenhouse gases; and
- 2) improving the efficiency of fossil energy systems.

The first strategy aims to eliminate concerns over emissions of greenhouse gases from fossil fueled energy systems. The second strategy seeks to improve the fuel-to-energy efficiencies of these systems, thus reducing pollutant emissions, water usage, and carbon emissions on a per unit of energy basis. Collectively, these two strategies comprise the Clean Coal Program's approach to ensure that current and future fossil energy plants will have options to meet all emerging requirements for a safe and secure energy future.

CORE RESEARCH AND DEVELOPMENT ACTIVITIES

The Clean Coal Program is addressing the key technical challenges that confront the development and deployment of clean coal technologies through research on cost-effective capture technologies; monitoring, verification, and accounting technologies to ensure permanent storage; permitting issues; and development of advanced energy systems. The Program is also actively engaged in interagency efforts to address liability issues, public outreach, and infrastructure needs. As an example, today's commercially available CCS technologies would add around 80 percent to the cost of electricity for a new pulverized coal plant, and around 35 percent to the cost of electricity for a new integrated gasification combined cycle plant.<sup>1</sup> The Program is aggressively pursuing developments to reduce these costs to less than a 35 percent increase in the cost of electricity for pulverized coal energy plants and less than

<sup>1</sup>Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity, U.S. Department of Energy/National Energy Technology Laboratory, DOE/NETL-2007/1281, Final Report, May 2007.

a 10 percent increase in the cost of electricity for new gasification-based energy plants.

Research is focused on developing technology options that dramatically lower the cost of capturing carbon dioxide (CO<sub>2</sub>) from fossil fueled energy plants. This research can be categorized into three technical pathways: post-combustion, pre-combustion, and oxycombustion. Post-combustion refers to capturing CO<sub>2</sub> from the stack gas after a fuel has been combusted in air. Pre-combustion refers to a process where a hydrocarbon fuel is gasified to form a mixture of hydrogen and carbon dioxide, and CO<sub>2</sub> is captured from the synthesis gas before it is combusted. Oxy-combustion is an approach where a hydrocarbon fuel is combusted in pure or nearly pure oxygen rather than air, which produces a mixture of CO<sub>2</sub> and water that can easily be separated to produce pure CO<sub>2</sub>. Collectively, research in each of these technical pathways is exploring a wide range of approaches such as membranes; oxy-combustion concepts; solid sorbents; CO<sub>2</sub> hydrates; and advanced gas/liquid scrubbing technologies. These efforts cover not only improvements to state-of-the-art technologies but also development of several revolutionary concepts, such as metal organic frameworks, ionic liquids, and enzymebased systems. Coupling these developments with other advances in efficiency improvements and cost reduction from developments in gasification, turbines, and fuel cells, will help provide a technology base for commercial deployment of fossil energy systems integrated with CCS.

The Department is the primary supporter of the National Carbon Capture Center (NCCC), which is a joint partnership between DOE and industry. The NCCC is a one of a kind, world class facility which offers an opportunity to validate capture technologies on actual gas from a coal fired power plant or gasification facility. Because of the ability to operate under a wide range of process conditions, research at the NCCC can effectively evaluate technologies at various levels of maturity for many different applications.

#### REGIONAL CARBON SEQUESTRATION PARTNERSHIPS

The Regional Carbon Sequestration Partnerships were created by the DOE in 2003 through a competitive solicitation. The Partnerships were designed to address a range of issues associated with geologic storage of CO<sub>2</sub>. The Clean Coal Program has been performing CCS field tests focused on injection, monitoring, verification, accounting and other aspects of geologic storage for many years, and the seven Regional Carbon Sequestration Partnerships are critical to this effort. These Partnerships are comprised of state agencies, universities, and private companies. They represent more than 400 unique organizations in 43 States, and four Canadian Provinces. Geographic differences in fossil fuel use and potential storage sites across the United States dictate the use of regional approaches in addressing CCS, so each Partnership is focused on a specific region of the United States and Canada that hold similar characteristics relating to CCS opportunities.

Together, the Partnerships form a network of capability, knowledge, and infrastructure that will help enable geologic storage technology to play a role in the clean energy economy. They represent regions encompassing 97 percent of coal-fired CO<sub>2</sub> emissions, 97 percent of industrial CO<sub>2</sub> emissions, 96 percent of the total land mass, and essentially all the geologic storage sites that can potentially be available for geologic carbon storage.

Regional Partnerships are drilling wells and injecting small quantities of CO<sub>2</sub> to validate the potential of key storage locations throughout the country. To date, the Regional Partnerships have injected over 1 million tons of CO<sub>2</sub> at 18 small scale injection projects throughout the United States and Canada. These tests have helped to validate storage at a small scale and understand the fate of CO<sub>2</sub> in different depositional systems containing saline water, oil, and natural gas. Several large scale projects are also underway that will inject several million tons of CO<sub>2</sub> over the life of the projects. One of these projects has safely and securely injected over 2 million metric tons of CO<sub>2</sub>. Several more large-scale field tests will begin later this year.

Over the course of these initiatives, DOE and the Partnerships are addressing key infrastructure issues related to permitting, pore space ownership, site access, liability, public outreach, and education. We are also jointly developing Best Practice Manuals on topics such as site characterization, site construction, operations, monitoring, mitigation, closure, and long-term stewardship. These manuals will serve as guidelines for a future geologic sequestration industry in their regions, and help transfer the lessons learned from DOE's Program to all regional stakeholders. Finally, DOE and the Partnerships continue to work closely with the Environmental Protection Agency (EPA) and other federal and state agencies in developing CCS

regulatory strategies, which will provide additional certainty for future CCS deployments.

#### DEMONSTRATIONS AT COMMERCIAL-SCALE

The success of the Clean Coal Program will ultimately be judged by the extent to which emerging technologies get deployed in domestic and international marketplaces. Both technical and financial challenges associated with the deployment of new “high risk” coal technologies must be overcome in order to be capable of achieving success in the marketplace. Commercial-scale demonstrations help the industry understand and overcome start-up issues, address component integration issues, and gain the early learning commercial experience necessary to reduce risk and secure private financing and investment for future plants.

The Department is implementing large-scale projects through the Regional Partnerships, the Clean Coal Power Initiative (CCPI), and FutureGen. Phase III of the Partnerships is focused on large-scale field tests of geologic carbon sequestration on the order of 1 million metric tons of CO<sub>2</sub> per year, and are addressing the liability, regulatory, permitting, and infrastructure needs of these projects. As described previously in this statement, the Partnerships have brought an enormous amount of capability and experience together to work on the challenges of these large projects.

The CCPI is a cost-shared partnership between the government and industry to develop and demonstrate advanced coal-based power generation technologies at the commercial scale. CCPI demonstrations address the reliability and affordability of the Nation’s electricity supply from coal-based generation. By enabling advanced technologies to overcome technical risks involved with scale-up and bringing them to the point of commercial readiness, CCPI accelerates the development of both advanced coal generation technologies and the integration of CCS with both new and existing generation technologies. The CCPI also facilitates the movement of technologies into the market place that are emerging from the core research and development activities. The CCPI program received an additional \$800 million from the 2009 American Recovery and Reinvestment Act (Recovery Act) which, in combination with base funding, was used to fund four active CCPI projects, two pre-combustion and two post-combustion projects. In addition, a CCPI round II project has been modified to demonstrate CCS at a new integrated gasification combined cycle power plant. We are working closely with the project developers to comply with NEPA, air and water regulatory requirements, and complete initial Front End Engineering & Design (FEED) studies for the facilities. All five of these projects are on track to be operational between 2013 and 2015.

The FutureGen Project intends to conduct novel large-scale testing to accelerate the deployment of a set of advanced oxy-combustion power production technologies integrated with CCS. This project will be the first advanced repowering oxy-combustion project to store CO<sub>2</sub> in a deep saline geologic formation. On August 5, 2010, Secretary of Energy Steven Chu announced an award of \$1 billion in Recovery Act funding to the FutureGen Alliance, Ameren Energy Resources, Babcock & Wilcox, and Air Liquide Process and Construction, Inc., to build FutureGen 2.0, a clean coal repowering program and carbon dioxide storage network. On February 28, 2011, the FutureGen Alliance selected Morgan County, Illinois, as the preferred location for the FutureGen 2.0 CO<sub>2</sub> storage site, visitor center, research, and training facilities.

In addition to the CCPI and FutureGen 2.0 projects, the Recovery Act has also helped fund more than 80 additional projects which includes three large scale Industrial CCS demonstrations, ten geologic site characterizations, forty-three university research training projects, seven CCS research training centers, six Industrial CCS projects focused CO<sub>2</sub> reuse, and 14 projects focused on accelerated component development in the core research program.<sup>2</sup>

#### CONCLUSION

CCS and related clean coal technologies can play a critical role in mitigating CO<sub>2</sub> emissions under many potential future carbon stabilization scenarios. Nevertheless, challenges remain to achieving cost-effective commercial deployment of CCS. The Department’s research programs are a vital step to advancing the readiness of clean coal technologies for future commercial deployment. I thank this Committee and its members for allowing me the opportunity to provide an overview of DOE’s research efforts in developing CCS technologies and I look forward to your questions. The Administration is still reviewing S. 699 and S. 757 and does not have a position on either bill at this time.

<sup>2</sup>Details about all of the Fossil Energy projects funded by the Recovery Act can be found here: <http://www.fossil.energy.gov/recovery/index.html>.

The CHAIRMAN. Thank you very much.  
Ms. Greenberg.

**STATEMENT OF SALLIE E. GREENBERG, ASSISTANT DIRECTOR, ADVANCED ENERGY TECHNOLOGY INITIATIVE, ILLINOIS STATE GEOLOGICAL SURVEY, CHAMPAIGN, IL**

Ms. GREENBERG. Mr. Chairman, Ranking Member Barrasso, distinguished members of the committee, thank you for the opportunity to testify before you today on S. 699.

The Illinois State Geological Survey at the University of Illinois is one of the largest and most diverse State geological surveys in the United States. Beginning in 2001 we have been researching carbon capture and storage in the Illinois basin of Illinois, Southwestern Indiana and Western Kentucky. We have led the Midwest Geological Sequestration Consortium, 1 of the 7 regional carbon sequestration partnerships supported by the U.S. Department of Energy since 2003.

In 2008, we began developing a one million metric ton demonstration of carbon dioxide capture and storage in collaboration with the Archer Daniels Midland Company in Decatur, Illinois. Injection is expected to begin at the rate of 1,000 tons per day in September 2011 and continue for the next 3 years. As a result of directly dealing with such issues as underground injection control permitting, pore space ownership, liability and community stakeholder engagement, we are pleased to offer our comments on S. 699.

We commend the criteria established in this bill to define a large scale injection to mean the injection of at least one million metric tons per year. To specify a set of project selection criteria that require the submittal of comprehensive geologic data and appropriate plans for environmental monitoring. We see these project selection provisions as requiring selective projects to be beyond the applied research stage. Applicants must demonstrate thorough knowledge of their proposed site based on existing information or new information such as geophysical surveys specifically obtained to validate their application to the Secretary.

A basic project will not and should not qualify. The Secretary, however, will require the staff to assure that the information submitted is adequate and complete in order to minimize the risk to the government and the taxpayer under the indemnification provisions. The recently adopted Class VI underground injection control or UIC regulations will also assure that many of the provisions of S. 699 are met.

These regulations require that underground sources of drinking water are protected and no injection project may proceed without a UIC permit. UIC regulations cover all aspects of carbon dioxide injection from site characterization to well construction and from operational monitoring to site closure. Many of the provisions in the UIC Class VI regulations are mirrored in the post injection and monitoring elements of S. 699 which in effect means that the U.S. EPA or State EPAs in States with primacy will have the leading enforcement rule. Close coordination in between the Secretary of Energy and these organizations will be required.

With respect to liability, risks during site operations and immediately following closure can be minimized through rigorous geological site characterization and excellent operational and site closure practices. Best practices guidelines have been developed for many of these activities based on the DOE's supported applied research conducted since 2003. We believe the indemnification provisions of S. 699 represent a backstop to new UIC Class VI regulations and to privately insurable activities that commercial carbon capture and storage operators will normally engage in such as the drilling of injection wells.

Beyond these requirements the government's indemnification is necessary to allow projects to proceed where the risk profile beyond post closure stewardship is poorly known. Given that it is in the public interest for carbon capture and storage to be thoroughly evaluated the provisions of S. 699 that allow for a pool of up to ten indemnified projects will help establish a risk profile that can inform long term liability under a fee supported structure. These projects must be carefully selected and monitored, however, to ensure that the indemnity is warranted at the outset and not abused by poor practices during project execution and post closure stewardship.

We would also suggest that the projects be selected in geologically diverse areas to maximize the understanding of relative risk. Excuse me.

Mr. Chairman and members, we appreciate the opportunity to submit these comments to the committee. Would welcome any follow up communications that would be useful to you.

[The prepared statement of Ms. Greenberg follows:]

PREPARED STATEMENT OF ROBERT J. FINLEY, DIRECTOR AND SALLIE E. GREENBERG, ASSISTANT DIRECTOR, ADVANCED ENERGY TECHNOLOGY INITIATIVE, ILLINOIS STATE GEOLOGICAL SURVEY, CHAMPAIGN, IL

Chairman Bingaman and Members U.S. Senate Committee on Energy and Natural Resources: The Illinois State Geological Survey at the University of Illinois is one of the largest and most diverse state geological surveys in the United States. Beginning in 2001, we have been researching carbon capture and storage in the Illinois Basin of Illinois, southwestern Indiana, and western Kentucky. We have led the Midwest Geological Sequestration Consortium, one of the seven Regional Carbon Sequestration Partnerships supported by the U. S. Department of Energy, since 2003. In 2008, we began developing a one million metric ton demonstration of carbon dioxide capture and storage in collaboration with the Archer Daniels Midland Company at Decatur, Illinois. Injection is expected to begin at the rate of 1,000 tonnes per day in September 2011 and continue for the next three years. As a result of directly dealing with such issues as Underground Injection Control permitting, pore space ownership, liability, and community stakeholder engagement, we are pleased to offer our comments on S.699.

We commend the criteria established in this bill to define a large-scale injection to mean the injection of at least one million metric tons per year and to specify a set of project selection criteria that require the submittal of comprehensive geological data and appropriate plans for environmental monitoring. We see these Project Selection provisions as requiring selected projects to be beyond the applied research stage. Applicants must demonstrate thorough knowledge of their proposed site based on existing information or new information, such as geophysical surveys, specifically obtained to validate their application to the Secretary. A basic research project will not and should not qualify. The Secretary, however, will require the staff to assure that the information submitted is adequate and complete in order to minimize the risk to the Government and the taxpayer under the indemnification provisions.

The recently adopted Class VI Underground Injection Control, or UIC, regulations will also assure that many of the provisions of S.699 are met. These regulations re-

quire that underground sources of drinking water are protected, and no injection project may proceed without a UIC permit. UIC regulations cover all aspects of carbon dioxide injection from site characterization to well construction and from operational monitoring to site closure. Many of the provisions of the UIC Class VI regulations are mirrored in the Post Injection and Monitoring Elements of S.699 which, in effect, means that the US EPA, or state EPAs in states with primacy, will have the leading enforcement role. Close coordination between the Secretary of Energy and these organizations will be required.

With respect to liability, risks during site operations and immediately following closure can be minimized through rigorous geological site characterization and excellent operational and site-closure practices. Best-practices guidelines have been developed for many of these activities based on DOE-supported applied research conducted since 2003. We believe the indemnification provisions of S.699 represent a backstop to new UIC Class VI regulations and to privately insurable activities that commercial carbon storage operators will normally engage in, such as drilling of injection wells. Beyond these requirements, the Government's indemnification is necessary to allow projects to proceed where the risk profile beyond post-closure stewardship is poorly known. Given that it is in the public interest for carbon capture and storage to be thoroughly evaluated, the provisions of S.699 that allow for a pool of up to 10 indemnified projects will help establish a risk profile that can inform long-term liability under a fee-supported structure. These projects must be carefully selected and monitored, however, to ensure that public indemnity is warranted at the outset and not abused by poor practices during project execution and post-closure stewardship. We would also suggest that the projects be selected in geologically diverse areas to maximize understanding of relative risk.

Mr. Chairman and Members, we appreciate the opportunity to submit these comments to the Committee and would welcome any follow-up communications that would be useful to you.

Mr. Chairman and Members, we appreciate the opportunity to submit these comments to the Committee and would welcome any follow-up communications that would be useful to you.

The CHAIRMAN. Thank you very much.  
Mr. Watson.

**STATEMENT OF MATT WATSON, SENIOR ENERGY POLICY  
MANAGER, ENVIRONMENTAL DEFENSE FUND**

Mr. WATSON. Chairman Bingaman, Ranking Member Barrasso, members of the committee: EDF appreciates the opportunity to appear in support of S. 699. Until we have a policy mechanism that internalizes the cost of carbon pollution and creates a true market for CCS, we won't see the technology perfected and deployed at scale. In today's context with the commercial basis for CCS in limbo and the prospects for new projects increasingly in question, we think the targeted rifle shot approach in S. 699 is an important and productive step in the right direction.

It's been suggested that the private market won't provide financial risk management tools for CCS projects and that operators will need unlimited and perpetual liability relief in order to go forward. EDF strongly disagrees with this assertion. There's no special liability relief for EOR projects or for underground injection of hazardous waste or geologic storage of natural gas. Under the right conditions CCS shouldn't present risks any greater than those posed by these activities, all of which appear to have little trouble attracting investment capital and risk management options in the marketplace.

We recognize, however, that as a new technology private sector insurance offerings for CCS are limited. Ultimately, it will take on the ground experience to generate the actuarial data on which a robust and well calibrated suite of risk management options can be built. S. 699 will help generate this on the ground experience. It

strikes an appropriate balance by providing limited indemnification to early CCS projects while putting 4 key protections in place to reduce the risk of moral hazard that's inherent to broad liability relief.

So I'd like to spend a minute on those protections because to EDF they're critical aspects of the bill.

No. 1, the bill is limited to ten projects. This should put future project operators as well as private insurers on notice that liability relief is not going to become a permanent fixture of the legal regime governing CCS. We anticipate the private insurance market and the CCS industry itself will respond by closely observing these ten demonstration projects and using the data generated there to develop insurance products to meet the needs of future projects.

No. 2, the bill requires project operators to seek financial assurances in the marketplace and only provides indemnification from liabilities over and above the coverage provided by those protections. Requiring project operators to have first dollar responsibility for damages is a critical step toward minimizing moral hazard.

No. 3, the bill requires recipients of indemnification agreements to pay risk based fees to cover taxpayer exposure for the ten projects. Risk based fees provide an important incentive for careful project planning, in particular as it relates to the critical issues of site characterization and site selection.

No. 4, project selection is competitive and is based on a number of eligibility criteria that can be thought of as underwriting standards. In particular requirements for detailed geologic characterization and requirements for thorough measurement monitoring and verification would serve as important thresholds for program participation.

By establishing a program that mimics risk management models that exist in the marketplace and by restricting the program to a limited number of early projects, S. 699 should help lay a foundation for the development of market based solutions to the industry's need to manage risk at a reasonable cost.

Finally a few words about the post closure stewardship aspects of the bill. EDF supports creation of a third party entity, adequately funded by industry to manage the routine maintenance and monitoring of properly closed sequestration sites. S. 699 goes beyond routine maintenance allowing DOE to take responsibility for remediation activities. The limited confines of this bill for these ten projects we believe this broad definition of stewardship is appropriate. However, when stewardship policies are crafted for future projects it would not be appropriate to transfer major remediation responsibilities or responsibilities for other liabilities that may arise to third party entities, again, because of the risk of moral hazard that this creates.

That concludes my written remarks other than to commend the Chairman and Senators Murkowski, Barrasso and Rockefeller for putting forward this important legislation. Look forward to the discussion.

[The prepared statement of Mr. Watson follows:]

PREPARED STATEMENT OF MATT WATSON, SENIOR ENERGY POLICY MANAGER,  
ENVIRONMENTAL DEFENSE FUND

Environmental Defense Fund (EDF) appreciates the opportunity to speak in support of S.699 as the Committee considers how to help early carbon capture and sequestration (CCS) projects conduct operations in a safe and effective manner and otherwise address risk management issues. Since 1967 EDF has linked science, economics and law to create innovative, equitable and cost-effective solutions to urgent environmental problems.

The primary challenges to CCS deployment are not technological. The component technologies exist today. Rather, the primary barrier is the lack of a commercial basis for deployment. Without a policy mechanism that internalizes the costs of carbon pollution—such as a declining cap on carbon emissions, or more robust regulatory requirements than are currently being contemplated—it is unlikely that we’ll see CCS deployment at scale. As such, costs will remain high and technology advancements will be slower than they would otherwise be.

However, the problem of climate disruption isn’t going away. As a society, it is something we will be forced to address, sooner or later, whether we like it or not. And EDF believes that successful deployment of geologic sequestration will be a critical technology option if we are to accommodate fossil energy in a carbon-constrained future.

EDF therefore supports moving forward with pilot projects than can help us begin the process of acquiring operational experience with CCS. We likewise favor moving forward judiciously in building up the legal and regulatory frameworks that will be necessary to support CCS commercialization.

Progress is being made on this front. For example, in December the EPA promulgated final rules for geologic sequestration of CO<sub>2</sub> under the Underground Injection Control program and for injection and geologic sequestration of CO<sub>2</sub> under the greenhouse gas reporting program. These rules represent important steps forward in laying the groundwork for CCS deployment.

As Congress and the Administration contemplate additional steps on the legal and regulatory front, though, it will be important to not get too far ahead of our on-the-ground experience. Decision makers should resist the temptation to intervene in the marketplace or create exemptions in fundamental laws that protect citizens and the environment in an attempt to solve problems or reduce barriers to CCS deployment that may not actually exist.

CCS DOES NOT PRESENT INHERENTLY UNIQUE FINANCIAL RISK MANAGEMENT  
CHALLENGES

It has been suggested that the private market will not provide adequate financial risk management tools for CCS projects and that operators will need unlimited and perpetual “liability relief” in order to move forward with CCS projects. EDF strongly disagrees with this assertion.

Under the right conditions, CCS should present risks no greater than those posed by any number of other similar activities. The IPCC Special Report on Carbon Capture and Sequestration concluded in 2005 that the local health, safety and environmental risks of CCS are comparable to the risks of similar underground injection and storage activities if there is “appropriate site selection based on available subsurface information, a monitoring programme to detect problems, a regulatory system and the appropriate use of remediation methods to stop or control CO<sub>2</sub> releases if they arise.”

With these protections in place, CCS projects should be able to secure risk management tools in the private marketplace, rather than rely on taxpayers to take on the liability risks associated with projects.

There is no special liability relief for the enhanced oil recovery business. Businesses engaged in the underground injection of industrial and hazardous wastes operate without any special liability relief. Natural gas storage operators are not shielded from liability. Firms in these industries face potential liability for their actions until normal statutes of limitation have run their course or the companies are relieved of liability through bankruptcy. Yet all of these businesses inject material into geologic formations and appear to have little trouble attracting investment capital and risk-management tools in the marketplace.

We recognize, however, that at this early stage the private sector has not yet developed a robust suite of risk management tools for CCS projects. At least one private-sector insurer is now offering policies for CCS projects. But ultimately it will take on-the-ground operational experience to generate the actuarial data on which a robust and well-calibrated suite of risk-management options can be built. Simi-



larly, on-the-ground experience will help banks and other investors better understand project risk, which should bring down the costs of capital over time.

#### S.699 IS A MEASURED APPROACH TO A TEMPORARY PROBLEM

Given these facts, EDF is willing to support temporary, limited and thoughtful intervention in the marketplace in order to acquire the operational experience that will support the development of a broader range of risk management options in the private sector. It is critical, however, that any such intervention put protections in place to avoid the problems of “moral hazard” that are inherent to broad liability relief.

Current liability rules, grounded in common law and statutes, serve an important purpose—encouraging people to take prudent and necessary steps to avoid putting fellow citizens and investors at risk. Privatizing economic benefits while socializing the associated risks through so-called liability relief increases the odds that short-cuts will be taken and warnings will be ignored, potentially leading to disastrous results.

S.699 strikes an appropriate balance between the need to provide limited indemnification to early CCS projects—in order to generate the operational experience that will allow the private sector to take over the task of financial risk management—and putting protections in place to reduce the risk of “moral hazard” for these early projects.

First and foremost, the indemnification program under S.699 is limited. Limiting the program to 10 projects puts future project operators, as well as private insurers, on notice that liability relief is not going to become a permanent fixture of the legal regime governing CCS. We anticipate the private insurance market will respond by closely observing the 10 demonstration projects and developing private insurance products to meet the needs of future projects. Likewise, expect the CCS industry itself will use the experience gained through the demonstration projects to develop self-insurance strategies and mutual insurance arrangements.

Second, in order to be eligible for an indemnification agreement, S.699 requires project operators to seek financial assurances in the private marketplace and only provides indemnification from liabilities over and above those privately-secured financial protections. Requiring project operators to have “first dollar” responsibility for any damages that may arise is a critical step toward minimizing moral hazard.

Third, S.699 requires recipients of indemnification agreements to pay risk-based fees to cover the taxpayer exposure for the 10 projects. Risk-based fees provide an important incentive for careful planning of CCS projects—in particular as relates to site selection, an issue of utmost importance to project safety.

Fourth, project selection is competitive and based on a number of eligibility criteria that can be thought of as “underwriting standards.” In particular, requirements for detailed geologic characterization and risk analysis and requirements for thorough measurement, monitoring and verification serve as important thresholds to protect taxpayers, local communities and the environment.

By establishing a program that mimics risk management models that exist in the marketplace, and by restricting the program to a limited number of early projects, S.699 should help lay a foundation for the development of market-based solutions to the emerging CCS industry’s need to manage financial risk at a reasonable cost.

#### POST-CLOSURE INFRASTRUCTURE MAINTENANCE—AN APPROPRIATE GOVERNMENT FUNCTION

Properly closed sequestration sites will require stewardship for long time periods even though there is sound basis to believe that properly planned and operated projects will present minimal risk in the post-closure period. EDF supports the creation of a third-party entity, adequately funded by industry, to manage the maintenance of properly closed sequestration sites. Ultimately the function might be privatized, but it makes sense for the government to perform this role for early projects.

The bill extends DOE’s post-closure stewardship obligations beyond simple infrastructure maintenance (plugging the occasional leaking well, conducting a low-intensity monitoring regime, etc.) to include “remediation activities to ensure the geological integrity of the site and prevent any endangerment of public safety.” Given the nature of the program established by S.699—one in which the government will indemnify eligible sites for damages that do not arise from gross negligence or intentional conduct—we believe this broad definition of stewardship is appropriate.

When long-term stewardship policies are crafted for future projects, however, we recommend that Congress re-consider the scope of any third-party stewardship program. Creation of a third-party entity for site maintenance is probably appropriate

for both early projects and later projects, but the optimum funding method, duties and obligations of the stewardship entity are likely to be different once the marketplace has had time to develop robust insurance offerings and other risk mitigation tools.

And while it may be appropriate to allow a future third-party entity to take on routine stewardship responsibilities, it would not be appropriate to transfer responsibility for remediation or other liabilities to a third-party entity in the post-closure phase. Again, this would raise the prospect of moral hazard. Certainly, decisions made during a project's operational phase could lead to problems that might not materialize until post-closure. Therefore, responsibility for liabilities that may arise should rest with the project operator, even in the event that a third-party entity takes on stewardship responsibilities.

#### ASSISTING STATE REGULATORY AGENCIES

EDF is pleased that the bill establishes grants to state agencies for employee training purposes. CCS projects raise a number of new regulatory issues and federal assistance in helping to educate state agencies regarding these issues is important.

The CHAIRMAN. Thank you very much.

Ms. Trabucchi.

#### STATEMENT OF CHIARA TRABUCCHI, PRINCIPAL, INDUSTRIAL ECONOMICS INCORPORATED, CAMBRIDGE, MA

Ms. TRABUCCHI. Mr. Chairman, Senator Barrasso, distinguished members of the committee, thank you for introducing S. 699 and for the invitation to testify at today's hearing.

I'm a Principal and Chief Financial Officer with Industrial Economics in Cambridge, Massachusetts. My expertise relevant to this matter is in financial insurance frameworks and long term indemnity models. My testimony focuses on the financial management in indemnification framework proposed in the bill. My remarks today address 2 specific aspects.

The first being the assessment, collection and use of fees from developers of CCS projects.

No. 2, the dollar delimited amount of indemnification included in the bill.

Firms seeking investment capital to finance business ventures including CCS must demonstrate the ability to assume and manage risks inherent to the venture. By doing so the firm is able to assure investors whether private or public that the value of their investment will not erode. In fact, over time will gain value.

In the case of CCS the use of taxpayer dollars in the very long time horizon demands a financial assurance structure that blends the strengths of private and public risk sharing. To be effective a financial assurance structure that implements private/public risk sharing should achieve 4 goals.

No. 1, it should ensure funds are adequate when needed.

No. 2, it should ensure these funds are readily assessable when needed.

No. 3, it should establish minimum standards for financial institutions providing funds or underwriting risk.

No. 4, it should insure continuity of financial assurances when ownership of sites is transferred.

The long term indemnity model proposed in S. 699 is a notable step forward in achieving these goals. However, to the extent the bill is designed to establish a financial management structure that ensures sufficient resources are available to pay for long term stewardship at the time of a demonstration projects are transferred.

Then in my view the following elements warrant additional clarification.

No. 1, in the section addressing collection of fees and the use of net present value analysis, the amount of fees assessed and collected should be based on the net present value of probable damages arising from each project. The analytic tools exist to estimate dollar values for potential damages and are routinely used by firms expert and financial and natural resource economics.

No. 2, consistent with basing fees on a net present value analysis, the fees collected should be investing the dedicated interest bearing account that generates a rate of return at least equal to the risk adjusted discount rate used in the net present value calculation. In the absence of doing so the fees collected may not yield sufficient revenue to avoid an intergenerational transfer of costs to future taxpayers.

No. 3, by design an appropriate fee structure should be adjustable whereby the CCS developer pays a risk adjusted, site specific fee that is reassessed as actual site specific monitoring, measuring and verification data become available.

No. 4, given the experimental nature of CCS and its limited commercial application insufficient information may exist about the risk profiles of a candidate demonstration projects to establish a limited liability today that appropriately adjusts for risk and uncertainty over the long term.

In my view pending the availability of such information and to provide a measure of certainty to markets interested in investing in CCS projects establishing a dollar delimited amount of indemnification for a discreet number of early mover demonstration projects may in fact be appropriate. But only if the stated public policy objective to accelerate the deployment of CCS technology. It is important to recognize that public financing of this sort distorts or eliminates the impact of market forces in determining what is or is not a rational risk neutral business venture.

With respect to the specific indemnification provisions included in the bill, as I understand the bill authorizes financial assistance for up to ten CCS demonstration projects with explicit provisions for project selection and financial responsibility. In my view by doing so the bill appropriately limits the overall risk exposure to the public to a discreet number of sites with a discreet array of selection criteria. Further, by limiting the timing of liability relief to after a defined period of post injection and by requiring that transfer of title be contingent upon performance based standards, the bill appropriately provides incentives for developers of CCS demonstration projects to properly operate and maintain their sites limiting the potential for future damages and public liability.

Finally, in the section addressing the amount of indemnification the language should state clearly that indemnification is applicable only to CCS related activities. A business entity or "person" underwriting a CCS project should not be allowed to package its operating activities in such a way as to yield an inappropriate risk transfer of preexisting non CCS related liabilities to the public.

In my view clarifying the language of S. 699, as I have suggested will help ensure continuity of financial assurances and provide a measure of certainty with respect to the long term stewardship of

CCS sites in a manner cognizant of and consistent with potential risks to the public. My written testimony elaborates on these areas. I would be pleased to answer any questions.

Thank you.

[The prepared statement of Ms. Trabucchi follows:]

PREPARED STATEMENT OF CHIARA TRABUCCHI, PRINCIPAL, INDUSTRIAL ECONOMICS  
INCORPORATED, CAMBRIDGE, MA

#### SUMMARY

Firms seeking investment capital to finance business ventures, including CCS, must demonstrate the ability to assume and manage risks inherent to the venture. By doing so, the firm is able to assure investors, whether private or public, that the value of their investment will not erode, and with time, will gain value. In the case of CCS, the very long time horizon and the use of taxpayer dollars demands a financial assurance structure that adequately protects the private and public investor.

To be effective, a financial assurance structure that implements private—public risk sharing should achieve four clear goals: (1) Ensure funds are adequate, when needed; (2) Ensure these funds are readily accessible, when needed; (3) Establish minimum standards for financial institutions providing funds or underwriting risk; and (4) Ensure continuity of financial assurances, when ownership of sites is transferred.

The long-term indemnity model proposed in Senate Bill 699 is a notable step forward in achieving these goals, and appropriately limits indemnification to certain types of damages. To the extent that Senate Bill 699 is designed to establish a financial management structure that ensures sufficient resources are available to pay for long-term stewardship at the time ownership of the demonstration projects is transferred, then, in my view, the following elements of the Bill would benefit from additional clarification:

1. In the section addressing Collection of Fees and the use of Net Present Value analysis, the amount of fees assessed and collected should be based on the Net Present Value of probable damages arising from each demonstration project. Damages associated with CCS projects are a function of site location and plant design; the analytic tools exist to estimate dollar values for potential damages and are routinely used by firms expert in financial and natural resource economics.

2. This section also should require the design of an adjustable fee structure, whereby the CCS developer pays a risk-adjusted, site-specific fee that is reassessed as actual site-specific monitoring, measuring and verification data become available.

3. Consistent with basing fees on a Net Present Value analysis, the fees collected should be invested in a dedicated, interest-bearing account that generates a rate of return at least equal to the risk-adjusted discount rate underpinning the Net Present Value calculation. In the absence of doing so, the fees collected may not yield sufficient revenue to avoid an inter-generational transfer of costs to future tax payers.

4. Given the experimental nature of CCS and its limited commercial application, insufficient information may exist about the risk profiles of the candidate demonstration projects to design a site-specific fee structure, today, that appropriately adjusts for risk and uncertainty over the long-term. Pending the availability of such information, establishing a dollar-denominated amount of indemnification for a discrete number of early-mover, demonstration projects may be appropriate.

Over the long term, I caution against establishing an arbitrary limit of absolute dollar liability. Rather, the amount of indemnification should be correlated to the pooled value of probable loss associated with the specific CCS demonstration projects subject to cooperative agreements under the Bill.

5. In the section addressing the amount of indemnification, the language should state clearly that indemnification is applicable only to CCS-related activities; a business entity (or 'person') underwriting a CCS project should not be allowed to package its operating activities in such a way as to yield an inappropriate risk transfer of pre-existing, non-CCS related liabilities to the public.

In my view, clarifying the language of Senate Bill 699 as I have suggested will help ensure continuity of financial assurances and provide a measure of certainty with respect to the long-term stewardship of CCS sites in a manner cognizant of,

and consistent with, potential risks to the public. In so doing, Senate Bill 699 will send a positive signal to private capital markets seeking to invest in CCS technology.

Thank you for the opportunity to testify in today's legislative hearing on Senate Bill 699, Department of Energy Carbon Capture and Sequestration Program Amendments Act of 2011. I am a Principal with, and the Chief Financial Officer of, Industrial Economics Incorporated in Cambridge, Massachusetts. My expertise is in finance and economics, with specific focus on financial assurance frameworks and financial indemnity models. Founded in 1981, Industrial Economics is a privately-owned professional services firm expert in the areas of financial and natural resource economics. The clients of the firm span the public and private sectors.

The focus of my testimony is on the financial management and indemnification framework proposed by Senate Bill 699. Below, I offer my overall assessment of Senate Bill 699, I highlight areas of the Bill with which I agree, and offer suggestions for consideration by the Committee. These suggestions are based on the language proposed in Senate Bill 699, and the Bill's intended objective of fostering early-mover deployment of no more than 10 Carbon Capture and Sequestration (hereinafter CCS) demonstration projects.

The sections that follow map to the provisions proposed by Senate Bill 699. Where appropriate, I highlight elements of the proposed language that are well designed; and I offer suggestions where the language of Senate Bill 699 might be clarified or improved.

#### OVERVIEW. THE IMPORTANCE OF FINANCIAL RESPONSIBILITY

Firms seeking investment capital to finance business ventures must demonstrate the ability to assume and manage risks inherent to the venture. By doing so, the firm is able to assure investors, whether private or public, that the value of their investment will not erode, and with time, will gain value. Under traditional financing models, investors require that risks be bounded, quantified and accounted for either directly as an expense, or indirectly through third-party financial instruments (letters of credit, surety bonds, insurance, to name a few).

CCS processes create a suite of risks, including possible injury to private and public sector interests, e.g., possible injury to natural resources, bodily injury and/or property damage. Traditional financing models presume that the project developer is an active business entity capable of setting aside funds today to pay for future obligations related to these risks. However, the objective of CCS is to store CO<sub>2</sub> in perpetuity, i.e., a period of time that transcends the typical business life cycle of many corporate endeavors. To the degree risks arising from CCS ventures continue beyond the operational life of the project, and in the event the CCS developer is no longer a going concern, prudent risk management dictates consideration of who will finance the obligations arising from these risks.

The use of taxpayer dollars and the very long time horizon associated with CCS—one which may extend beyond the natural life of the corporate entity undertaking the demonstration project—demands a financial management solution that blends the strengths of private and public risk sharing. To be effective, a financial assurance structure that implements a private—public risk sharing should achieve four clear goals:

- (1) Ensure funds are adequate, when needed;
- (2) Ensure these funds are readily accessible, when needed;
- (3) Establish minimum standards for financial institutions providing funds or underwriting risk; and
- (4) Ensure continuity of financial assurances, when ownership of sites is transferred.

To the degree society wishes to reduce greenhouse gas emissions, and the portfolio of emission reduction technologies includes CCS, then an effective financial assurance and indemnification framework will balance the four above-listed goals with needed incentives to foster the safe deployment of a limited number of early mover, demonstration projects.

If modified as I suggest below, the design of the financial assurance framework and the implementation of private—public risk sharing as proposed in Senate Bill 699 should provide a measure of financial and legal certainty with respect to the long term stewardship of CCS sites in a manner cognizant of, and consistent with, potential risks to the public. In so doing, Senate Bill 699 sends a positive signal to private capital markets seeking to invest in CCS projects.

## PROJECT SELECTION CRITERIA

In my view, the science-based criteria and provisions for project selection as proposed by Senate Bill 699 are necessary but not sufficient to underpin the financial management structure defined in later sections of the Bill. Additional provisions requiring the explicit evaluation of potential human health and environmental impacts from a financial perspective—deriving expected and maximum loss values with a clear understanding of the statistical range of possible outcomes—are needed for each proposed demonstration project.

The outputs of these evaluations will achieve three objectives.

First, they will help the implementing agency assess competitive bids for demonstration projects, and make an informed decision as to the potential financial risk posed by each demonstration project.

Second, they will provide an appropriate basis to calculate the amount of financial assurance that should be set aside by the individual CCS developer during the operating lifecycle of the CCS project, and for a defined period post-injection.

Third, to the degree the Secretary agrees to indemnify recipients of cooperative agreements for CCS demonstration projects, they will inform the amount of indemnification that is warranted.

## TERMS AND CONDITIONS (FINANCIAL ASSURANCE)

In my view, as proposed by Senate Bill 699, the CCS developer should remain financially responsible for events that occur during the operating lifecycle of the CCS project, and for a defined period post-injection. Specifically, financial assurances should be secured and maintained by the developer of the CCS demonstration project until such time as title to the site is transferred and accepted by the implementing Federal agency. In this way, the Bill provides incentives for CCS developers to properly operate and maintain their sites, limiting the potential for future damages. Firms are more likely to undertake design and operating decisions that minimize environmental (and remediation) costs, if they are held financially accountable.

Further, maximum flexibility should be afforded to developers of the early mover demonstration projects in selecting the financial instruments that may be used, including but not limited to trust funds, letters of credit, surety bonds, insurance, and self-insurance through a corporate financial test or corporate guarantee, or any combination thereof. The array of acceptable financial instruments must ensure that funds are adequate if and when needed, and readily accessible to pay for delineated activities. For this reason, minimum standards are necessary for financial institutions securing funds or underwriting CCS risks.

## INDEMNIFICATION AGREEMENTS

*Exception for Gross Negligence and Intentional Misconduct*

In my opinion, Senate Bill 699 appropriately limits indemnification to certain types of damages. The exception provided in Senate Bill 699 for gross negligence and intentional misconduct is important, particularly as it relates to fraud and misrepresentation of site (monitoring, measuring and verification) data. The importance of this exception can not be overemphasized, because these data likely will be used to underpin financial assurances, fee calculations and indemnification amounts.

*Collection of Fees*

I believe it is appropriate to assess and collect fees from the CCS developer to finance the cost of long-term stewardship. In my view, the language proposed by Senate Bill 699 should be clarified to ensure that the amount of fees collected is not arbitrary or based on a fixed rate for all sites. Establishing a blanket fixed fee to be paid by all CCS developers regardless of their individual site characteristics, operational methods and potential for consequences results in an inefficient use of available resources which otherwise could be invested for productive economic purposes. From a financial perspective, establishing a fixed rate of financial assurance that is paid by all CCS developers results in some developers paying more, and others less, than their fair share, because of differences in site attributes. Further, without strong oversight regarding site selection and fund management, and a clear process by which the amount of fees collected are periodically evaluated against the risk profiles of pooled sites, there is no reason to believe that the amount of funds collected will map to the actual financial resources needed to address long-term care expenses and delimited compensatory damages.

If the intent of Senate Bill 699 is to ensure a fee structure whereby the CCS developer pays a risk-adjusted, site-specific fee, then additional clarifying language in

the section of the Bill that addresses the criteria for determining the amount of the fee to be collected is prudent. In my opinion, this fee should be based on the Net Present Value of the future expected losses for each individual demonstration project. Specifically, damages associated with CCS projects are a function of location and plant design (including fuel source and technology), and therefore probable loss scenarios can be derived from each project's site characterization and risk assessment plans. These analyses provide an indication of 'how bad it could get' if an adverse event related to a CCS project were to occur, as well as a measure of the expected amount of funds required for remediation and to compensate for harm or injury, taking into account the probability of an event arising.

The amount of money collected from each CCS developer should directly correlate to the funds needed for long-term stewardship once ownership of their specific site is transferred. A 'one-size-fits-all' approach will result in perverse financial incentives, whereby poorly designed, sited and operated sites may be allowed to proceed without 'paying' for their share of prospective risk; allowing exclusions for a subset of sites will exacerbate these incentives, contributing to market distortions and the potential for moral hazard.

The use of Net Present Value analysis is accepted practice for funds management within the financial community; in addition, the analytic tools exist to estimate the expected range of dollar values for potential damages on a site-specific basis. Similar tools are used by: (1) firms, such as insurers, in the risk management industry; (2) firms in the financial sector; and (3) firms with expertise in human health and natural resource economics.

Additional clarifying language is warranted with respect to the timing of when such fees will be paid by the CCS developer. To ensure continuity of financial assurance during active site injection, post-injection, and through long-term stewardship, the amount of fees collected from the CCS developer should be established either as an up-front payment or as a payment over time during the operating lifecycle—the period of active injection—of the demonstration project. If the intent of Senate Bill 699 is not to delay the collection of fees until the end of the project, when there is the danger that the CCS developer may not have the resources available to pay the fees, or until an event or claim arises, then the language of the Bill should clearly state this. Provisions should be made at the outset of the demonstration project for the possibility of future bankruptcy or financial distress of the developer of the CCS demonstration project.

As the provisions proposed by Senate Bill 699 relate to a limited number of demonstration projects, and the public is assuming a measure of financial risk, the fees should be reassessed as information about the risk profiles become available. Practical reality should inform the application of financial theory. For example, if actual site monitoring, measuring and verification data demonstrate a declining risk profile and a reduced dollar value of future expected loss, the Net Present Value calculation underpinning the fee collection should be adjusted to reflect this situation, and the CCS developer should pay less in fees. Overfunding a long-term financial structure benefits neither the private sector nor the public sector. However, the inverse is also true—if monitoring, measuring and verification data suggest an increasing risk profile—the fees assessed should reflect the incremental increase in potential harm that may arise from the occurrence of an adverse event.

Establishing an adjustable fee structure that is based on the results of actual monitoring, measuring and verification data ensures that the CCS developer is rewarded for design and operating decisions that minimize future risk, and by extension future loss. Further, underpinning the financial management structure proposed by Senate Bill 699 with an adjustable fee structure that reflects the evolution of site risks over time ensures that the financial instruments used for purposes of financial assurance can be scaled up or down in response to site-specific differences.

Analyses underpinning the Net Present Value calculation proposed by Senate Bill 699, and the determination of how much to collect in fees, should be developed prior to entering into an indemnification agreement. These analyses should be transparent, identifying key assumptions regarding the timing of probable payments and an appropriate risk-adjusted discount rate. The public should know what it is financing, especially if there is the expectation that these fees will be passed through to end consumers in the form of increased energy rates. Further, to the degree other projects (beyond the early mover demonstration projects) come on-line, the data generated as part of these early mover efforts should inform the financial assurances and design of financial management strategies for long-term stewardship of subsequent projects.

*Use of Fees (Net Present Value and the Importance of Funds Management)*

In my view, the use of Net Present Value analysis as proposed in Senate Bill 699 is effective only if the money that is collected is set aside in a dedicated, interest-bearing account that generates a rate of return at least equal to the risk-adjusted discount rate underpinning the Net Present Value calculation. In the absence of doing so, the fees collected may not yield sufficient revenue to avoid an inter-generational transfer of costs to future tax payers.

The portion of funds collected that is not required to meet annual withdrawals should be invested in interest-bearing obligations of the United States.<sup>1</sup> Other long-term liability and federal indemnity models, including the Hazardous Substances Superfund,<sup>2</sup> the Oil Spill Liability Trust Fund,<sup>3</sup> and the Harbor Maintenance Trust Fund,<sup>4</sup> to name a few, adopt a similar investment strategy. Further, the Secretary of the Treasury should rely on the implementing agency, as established by Senate Bill 699, to provide information on the annual funding needs of the program, either as it may relate to the payment of claims following acceptance of title to the CCS demonstration project, or for purposes of long-term monitoring activities.

Ensuring that the language of Senate Bill 699 clearly articulates the intent of Congress in assessing, collecting and using fees from the developers of CCS demonstration projects will help to avoid future litigation over how much should have been collected in fees, how much was collected in fees, and what happened to the fees that were collected.

*Contracts in Advance of Appropriations—Limitation*

I am persuaded that investing in a limited number of CCS demonstration projects through a public financial assistance program is prudent. In my view, the financial management and indemnification framework as set forth in Senate Bill 699 provide a measure of financial and legal certainty with respect to long term stewardship of CCS sites in a manner cognizant of, and consistent with, potential risks to the public. In so doing, Senate Bill 699 sends a positive signal to private capital markets seeking to invest in CCS projects.

All else being equal, site-specific, risk-based pricing is predicated on the premise that the amount of funds collected over the life of the CCS project equals the amount of funds necessary to hedge financial obligations arising from project risks in the long-term. This is particularly true if the fees are regularly adjusted to reflect evolutions in the project's risk profile over time. However, given the experimental nature of CCS and its limited commercial application, insufficient information may exist about the risk profiles of the individual demonstration projects to design a site-specific fee structure, today, that appropriately adjusts for risk and uncertainty over the long-term. Therefore, pending the availability of such information, establishing a dollar-delimited limitation of liability for a discrete number of early mover, demonstration projects may be appropriate.

However, over the long term, any limitation of liability (i.e., dollar-denominated amount of indemnification) should not be arbitrary in design. Establishing an arbitrary limitation of liability contributes to unreasonable expectations and fosters misunderstanding with respect to the amount and timing of funds necessary for the responsible deployment of CCS. Perhaps more importantly, arbitrary limits of absolute dollar liability can result in moral hazard arising, because the CCS developer believes itself insulated from risk, and therefore may act less prudently with respect to how it sites and operates its project. Rather, the amount of indemnification should be correlated to the pooled value of probable loss associated with the specific CCS demonstration projects subject to cooperative agreements under the Bill.

As the provisions proposed by Senate Bill 699 relate to a limited number of demonstration projects, and the public is assuming a measure of financial risk, the amount of indemnification should be reassessed as information about the risk profiles of the CCS demonstration projects becomes available. Finally, if the intent of Senate Bill 699 is to provide financial certainty with respect to long term stewardship, then additional clarifying language in the section of the Bill that addresses limitations of liability is warranted.

<sup>1</sup> 26 U.S.C. 9602

<sup>2</sup> See Comprehensive Environmental Response, Compensation, and Liability Act § 221, 42 U.S.C. 9631 (2007), Superfund Amendments and Reauthorization Act § 517, 42 U.S.C. 9601(11) (2006), 26 U.S.C. 9507 (Hazardous Substance Superfund).

<sup>3</sup> See Oil Pollution Act § 1001(11), 33 U.S.C. 2701(11) (2007). 26 U.S.C. 9509 (Oil Spill Liability Trust Fund).

<sup>4</sup> See Act of May 13, 1954 (commonly referred to as the "St. Lawrence Seaway Act") § 13(a), 33 U.S.C. 988(a). Water Resources Development Act § 210(a), 33 U.S.C. 2238(a) (2007). 26 U.S.C. 9505 (Harbor Maintenance Trust Fund).



First, with respect to the amount of indemnification proposed by the Bill, the language in this subsection should apply only to CCS-related activities underpinning each demonstration project subject to cooperative agreement. Blanket indemnification should not be provided to 'all persons indemnified in connection with an agreement' irrespective of activity. In the absence of clearly delineating that the amount of indemnification is applicable only to CCS-related activities, a business entity (or 'person') underwriting a CCS project could package its operating activities in such a way as to yield an inappropriate risk transfer of pre-existing, non-CCS related liabilities to the public.

Second, as written, the Bill leaves open to interpretation whether the \$10 billion amount of indemnification applies to the collective pool of CCS demonstration projects, or whether each CCS demonstration project is subject to an individual amount of indemnification equal to \$1 billion per project. In my view, of the two options, the more effective means of protecting the public against financial risks associated with the early-mover CCS demonstration projects over the long-term would be to apply the amount of indemnification to the collective pool. Notwithstanding, if the intent of Senate Bill 699 is to establish per project indemnification, then additional clarifying language is warranted to address what happens if a single CCS demonstration project exceeds its per project limit of liability.

#### FEDERAL LAND

The same financial and legal provisions, with respect to financial assurances and indemnification, should exist regardless of whether the CCS demonstration project is sited on private lands, public lands or tribal lands. The failure to establish the same financial provisions for demonstration projects sited on public or tribal lands as for those sited on private lands may result in: (1) poor operating decisions and lack of appropriate site selection, because the project developer is not held financially accountable for its business decisions; and/or (2) provide an unintended subsidy or competitive market advantage to developers of demonstration projects on public or tribal lands.

#### CONCLUSION

The use of tax payer dollars and the very long time horizon associated with CCS—one which may extend beyond the natural life of the corporate entity undertaking the demonstration project—demands a financial assurance structure that blends the strengths of private and public financing and risk management tools. In my view, a financial assurance structure that successfully implements private—public risk sharing should achieve four clear goals:

- (1) Ensure funds are adequate, when needed;
- (2) Ensure these funds are readily accessible, when needed;
- (3) Establish minimum standards for financial institutions providing funds or underwriting risk; and
- (4) Ensure continuity of financial assurances, when ownership of sites is transferred.

To the degree society wishes to reduce greenhouse gas emissions, and the portfolio of emission reduction technologies includes CCS, then an effective financial assurance and indemnification framework will balance the above-listed goals with needed incentives to foster the safe deployment of a limited number of early mover, demonstration projects. The long-term indemnity model proposed in Senate Bill 699 is a step forward in accomplishing this objective.

However, if the intent of Senate Bill 699 is also to establish a financial assurance structure that ensures sufficient funds are available to pay for long-term stewardship at the time ownership of the demonstration projects is transferred, then the Bill would benefit from the modifications that I outline above. Finally, ensuring that the language of Senate Bill 699 clearly articulates the intent of Congress in assessing, collecting and using fees from the developers of CCS demonstration projects will help to avoid future litigation.

The CHAIRMAN. Thank you very much. Let me ask a few questions.

Ms. Greenberg, let me ask you first. This project that you folks are involved with with Archer Daniels Midland that's beginning here in September, as I understand, the first of September you're going to start injecting a thousand tons of CO<sub>2</sub> per day.

Ms. GREENBERG. That's correct.

The CHAIRMAN. How have you dealt with the issue of potential liability in connection with that project?

Ms. GREENBERG. Thank you for your question, Senator. The Midwest Geological Sequestration Consortium approached Archer Daniels Midland back in 2007 having done considerable amount of geologic site characterization in the Illinois Basin region itself and then more specifically in that area of Illinois. So we came to ADM with a significant amount of geologic knowledge and understanding of what the benefits of the rock units in the area are for carbon capture and storage.

We were very fortunate in that Archer Daniels Midland has a considerable amount of experience in the operation and handling of liquid carbon dioxide. So while the subsurface component of storing carbon dioxide was new to them and unfamiliar to them, the surface and operational handling of that carbon dioxide was actually something they were quite familiar with. So we were able, through a series of board meetings and meetings with their legal counsel and a variety of other individuals in the core processing and operations to bring them along with respect to their comfort level with respect to carbon—excuse me, carbon capture and storage.

In addition to that I will say that the carbon capture storage, this project and the plume of carbon dioxide stored in the subsurface is expected to stay wholly with on underneath ADM owned lands. So there has been no additional liability protection that's been undergone for the particular project.

The CHAIRMAN. OK.

Mr. Klara, let me ask you. We had a hearing earlier this week here where we had various experts talking to us about enhanced oil recovery and the use of CO<sub>2</sub> in enhanced oil recovery. The complaint that we heard pretty loud and clear was they didn't have enough CO<sub>2</sub>. That there was a much more demand for CO<sub>2</sub> to—for use in enhanced oil recovery than they could find.

There was very little concern raised. We didn't—the subject of the hearing was not focused on liability, potential liability. But my impression is that this whole issue of liability is one that the oil and gas industry basically blew right past in all of their use of CO<sub>2</sub> as enhanced oil recovery.

Am I wrong about that? Is there anything in place to deal with the liability problems that they encounter in use of that CO<sub>2</sub>?

Mr. KLARA. I'll even give you a step backward in terms of just within the Department's portfolio. There are upwards of 25 plus projects that are drilling. Many have already injected CO<sub>2</sub> in the ground. That several of those projects do relate to EOR, many don't.

The department has no ability to provide indemnifications. So the requirement for proposers was that you would have to figure out a way to find indemnification elsewhere or we would be unable to accept the project. We were able to fill our portfolio of projects.

I think, as Sallie indicated, what has happened amongst all the projects is it really required a lot of due diligence on their part in finding partners that really believed in the need for future CCS. We were willing to—and I think generally speaking, use their private mechanisms of assurances to deal with the liability issues. Now having said that, certainly we are aware as well that there are

many potential proposers that will not come to the table with ideas because of the fear of liability.

So what I can tell you is the projects that are out there, especially the ones like EOR, where there's a value added aspect to it, that the liability issue seems to not get much chatter and attention.

The CHAIRMAN. Thank you very much.

Senator Barrasso.

Senator BARRASSO. Thank you very much, Mr. Chairman.

I would like to ask Ms. Trabucchi just along the line of what Mr. Klara was talking about, the issue of giving the private sector some legal framework that they can understand and then maybe bringing others to the table. This bill does provide steps that an applicant must demonstrate to receive the long term indemnification. One of the things that the indemnification agreement section of the bill says. The language says, "The Secretary may agree to indemnify a project 1 year after the completed application is submitted."

Does the term may provide adequate certainty for a company and for potential investors?

Ms. TRABUCCHI. In my view actually it does.

I think what your investment community is looking for and what your capital markets are looking for in the form of certainty is the appreciation that the return on their investment will mature with time and gain value. I think if you create an indemnification provision that says will, no matter who you are. You enter into the cooperative agreement. You will receive indemnification.

What ends up happening is you provide the potential for perverse incentive where you have created a cap of liability. If it's an arbitrary limit, say it's just a random number. Then you are encouraging those actors to manage to that number without perhaps taking the necessary steps in place to do the performance based limits that are so much a function of the cooperative agreement.

So what I like about the use of the word may, is it leaves it to the Secretary to make a determination whether or not that indemnification is negotiated at the outset of the cooperative agreement based on the information provided by the site or whether that indemnification is negotiated throughout the life of the site. As information becomes available because these are experimental projects, the Secretary may decide that, you know, they're not doing their due diligence managing the projects correctly. So, no, we're going to protect the public's risk by not offering indemnity.

So in my view I think it provides adequate coverage.

Senator BARRASSO. Great.

Ms. TRABUCCHI. Certainty to the capital market.

Senator BARRASSO. That's kind of what I heard from Mr. Watson as well, along with that thought process.

Could I ask you as well, Ms. Trabucchi, if this bill were signed into law how you think it would impact investor interest including interest in carbon capture and sequestration projects even beyond the first ten?

Ms. TRABUCCHI. You mean more for scaling up for commercial applications?

Senator BARRASSO. Yes.

Ms. TRABUCCHI. You know, in my view what—in my view the bill if signed into law as it's currently configured would certainly foster capital investment in the ten demonstration projects with certainty. I think beyond that my sense is the capital—you know, it's the early entrants. It's the curve of your financial markets.

So those who are the early entrants who are willing to bear the risk are likely to bear the greater reward. So I think what this bill will do is create more of a competitive interest within the capital markets to invest in the ten projects. I think the real question is after those ten projects is there sufficient capacity for greater commercial application?

If there is additional capacity then what you're going to have is perhaps a more mature functioning market whereby your investors are more likely to be willing to invest because somebody else absorbed the risk on their behalf. So I'll leave it at that.

Senator BARRASSO. Thank you.

Mr. Klara, if I could just visit with you for a second? Researchers around the world are looking at geo-engineering as a potential approach to this issue of excess carbon dioxide. The focus of the one bill that we're looking at today, Direct Air Capture, follows a similar approach of using technology in innovation. Do you think the geo-engineering or direct air capture is a potential option at this point?

You know, there's been a lot written. Even the New York Times earlier this week had an article about it.

Mr. KLARA. Certainly it represents a very high risk option in terms of just the availability of technology to do so. Just generally speaking the portfolios, certainly in our portfolio, have focused primarily on looking at capturing large, high percentage quantities, which the bill recognizes. We have looked at, to some degree, these options for direct air capture. In every case we're just finding insurmountable barriers in terms of cost.

Senator BARRASSO. Cost.

Mr. KLARA. Other things like, for example Princeton is mentioned. Another issue there too, which you may be aware, at the end of the day it's going to all be about how many tons you take out of the atmosphere. So obviously out of the air when it's 380 parts per million, you have to process a lot of air to get one ton of carbon dioxide. That's another factor that leads into this cost issue.

So is it possible? Perhaps. Are there many technological barriers to it? Absolutely.

Senator BARRASSO. You know it's interesting in that recent article that Columbia professors disagreed with the Princeton professors as the cost and what the technology would be which makes me get to the final question, Mr. Chairman, is that what do think about the use of prizes as an effective way to try to spur private investment and then looking for ways to lower the cost?

Mr. KLARA. Certainly within our program we've never taken that approach. But if that approach certainly stimulates, you know, the best minds in the country, if not the world, to do so, we'd certainly encourage that.

Another aspect too, that we've tried in the past is often what happens in an area you kind of get bogged down in discipline. So

for example, it's obviously geologists, chemical engineers. So we even tried to expand beyond that to get some interest from any diverse, you know, subset of education leaders, scientists. So if the prize can kind of encourage that as well I think that would be very valuable.

Senator BARRASSO. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you.

Senator MANCHIN.

Senator MANCHIN. Thank you, Mr. Chairman. To all of you, thank you for being here.

If I could and I think the first question will go to Mr. Klara. But you know the whole thing that with technology today and where we stand with CCS we faced this with acid rain back in the 1980s as you recall. At that time you all had worked and developed a technology with scrubbers, low nox boilers. There was an alternative with how we would fix it. It was fixable because it was technology.

You all have an impressive record at NETL. I've been there many times and have gone through the process. Are you close to getting something that's commercial able and also affordable other than just the capture and storage? Because with the CO<sub>2</sub>, I mean, the SO<sub>2</sub> that we were able to, the sulphur, that we were able to capture. We were able to create a whole nother industry.

Mr. KLARA. Right.

Senator MANCHIN. With the low nox boilers. But now the Federal Government has taken a position unless we can find a way to effectively capture CCS you can't move forward with any projects. It doesn't make any sense at all because technology has not developed or matured enough.

How close are you and how much—I know that the Department of Energy, you all have been on the front end. Are you still in that position or are they putting all their effort toward you all finding the cure?

Mr. KLARA. Certainly within the CCS portion of our program, we have a program designed to try to reduce those barriers. As you point out many good points, right now it's a very expensive technology and likely too prohibitive under many scenarios to go forward. We have a 10-year plan, roughly a 10-year plan.

Senator MANCHIN. But basically you all agree that the Federal Government has taken a position, everything stops, nothing happens unless CCS is implemented. We don't have the technology in place. Would that be a fair statement?

Mr. KLARA. I can only comment on the technology side. On the technology side it's a very expensive option right now. However, if you look at our portfolio that there are many developments potentially emerging that we believe within a 10-year span will drive these costs and risks down to such a point that then it might be a whole new dynamic of how these technologies—

Senator MANCHIN. Such as scrubbers and low nox did for the acid rain?

Mr. KLARA. Exactly. In fact when developing these kinds of technologies we often look at those kind of past learning curves to try to get some insights into the kind of timing we might need to drive those costs and increase those performance.

Senator MANCHIN. Is NETL playing a significant role in administering? Do you all see that in the future you're going to play a significant role or is DOE are they fracturing this off and going in different directions?

Mr. KLARA. Yes, we have—I don't have any indications that would not say that NETL would play a key role.

Senator MANCHIN. How's your funding?

Mr. KLARA. Adequate.

Senator MANCHIN. What was the recommendation from DOE for your funding?

Mr. KLARA. For what year, sir?

Senator MANCHIN. For this coming year.

Mr. KLARA. For fiscal year 2011?

Senator MANCHIN. 2011.

Mr. KLARA. With a continuing resolution, we stayed stagnate.

Senator MANCHIN. How about 2012?

Mr. KLARA. For 2012, there is a slight reduction due to the fiscal constraints we're all under.

Senator MANCHIN. Alright. Also, with what's going on around the country, around the world, you have India. You have, of course, China. We hear so much about what China has been doing as far as in this arena.

Do you see them making significant strides because there's no limit or no restraints on them from being able to use different types of technology?

Mr. KLARA. From what we've seen on the technical side is that they definitely are showing interest. In fact, we have technical collaborations with most of those countries relative to what our researchers are doing and what they're doing. So from a technology standpoint, we've seen a lot of interest and potential there.

I would kind of use an analogy that if you look back at the kind of technologies you're mentioning for NO<sub>x</sub> and SO<sub>x</sub> that have been developed out of the Federal Government that those are the technologies that are leading the way in these emerging countries. So, you know, using that as the potential analogy and, you know, I would say that—

Senator MANCHIN. Is China using, I mean, are they using the scrubbers and the low NO<sub>x</sub> boilers? Are they going NO<sub>x</sub> and SO<sub>x</sub> in China?

Mr. KLARA. Yes, there are using the—

Senator MANCHIN. For their new are they retrofitting their old or taking their old?

Mr. KLARA. They're using the latest technologies, many and most of which have come out of the Federal Government's past portfolio. All indications are, at least from a technology exchange standpoint, that they would continue to do that with U.S. leadership and the technologies that we develop.

Senator MANCHIN. Would it be a fair statement to say that we don't have the technology in place to basically that would handle the CCS, if you will, carbon capture whether it's the storage or the—have we come close to finding any technology that would be able to take the waste of carbon CO<sub>2</sub> and turn that into a useable fuel?

Mr. KLARA. At this point we categorize those as reuse opportunities. So generally speaking with storage you put it underground and it's—

Senator MANCHIN. I know from that. But—

Mr. KLARA. Yes. But from a standpoint of looking at CO<sub>2</sub> reuse opportunities which means converting CO<sub>2</sub> to some other product.

Senator MANCHIN. Right.

Mr. KLARA. Like aggregates or—

Senator MANCHIN. Yes.

Mr. KLARA. Other chemical products. We have a small portfolio looking at that. It does become a key issue that CO<sub>2</sub> is such a stable molecule that it's often very expensive, high pressures, high temperatures, to convert it to these other products.

So people are looking at trying to look at creative mechanisms, chemistry and otherwise, to make that a reality. But right now in nearly every case that is in our portfolio, the costs are still too prohibitive for that options, those options.

Senator MANCHIN. So CCS is about the only viable option that we have right now?

Mr. KLARA. Even with CCS it's very costly. But yes, it does appear to be the lower cost option of those other alternatives.

Senator MANCHIN. Thank you, sir.

The CHAIRMAN. Senator Portman.

Senator PORTMAN. Thank you, Mr. Chairman. Thanks to the panelists here. I'm going to follow up, if I could, on some of the questions that Senator Manchin raised.

We had testimony earlier this week in committee regarding oil recovery, tertiary recovery particularly and the use of CO<sub>2</sub>. The comment was made by some of the industry experts that there's not an adequate supply of CO<sub>2</sub> for that kind of recovery. So I guess, Mr. Klara and others, feel free to chime in, in talking about the uses of CO<sub>2</sub> understanding that it's very expensive to convert it to an energy use as you said.

But what's the relationship here between capture, transportation, sequestration on the one hand and on the other hand this need that the oil and gas industry appears to have for additional CO<sub>2</sub> for recovery efforts?

Mr. KLARA. In a sense it's a chicken and an egg scenario. The problem becomes that right now there are capture technologies that go out there and capture CO<sub>2</sub> in large quantities that could be used for everything from EOR and other. The problem there is it's too costly of a source currently with the capture technologies that we have available.

So what I would say, relative to EOR, that it's the logical. If CCS becomes well deployed into the future that EOR will certainly be one of the first options that are pursued as we start to unroll CCS out. But that will be pursued only when we get the cost of these technologies down.

As I was commenting to Senator Manchin is that if we look at our 10 year road map, we are hopeful that we can drive the cost of those technologies down over the course of 10 years. At that time we would potentially be able to capture these large quantities of CO<sub>2</sub> at costs that can be acceptable to the oil industry for enhanced oil recovery.

Senator PORTMAN. Is EOR sequestration?

Mr. KLARA. A good point there as well. With those kinds of exchange options you will logically hear well, aren't you just putting carbon in the ground to produce carbon? There's a little bit of truth to that.

We've looked at it from a resource portfolio standpoint right now if you look at today's practices for EOR. How much CO<sub>2</sub> you put in the ground for how much oil you recover. You put about 80 percent of the carbon in the ground compared to the emissions you'd produce from the oil.

Now if we go into a CCS dominated environment where all of sudden there's a cost to the CO<sub>2</sub> and maybe a cost to keep it underground.

Senator PORTMAN. Right.

Mr. KLARA. We've looked at new reservoir management practices where all of a sudden now you could put 120 percent of the carbon in the ground that you'd produce. So the bottom line is we still do believe that there's a storage potential to that if indeed CCS begins to roll forward. CO<sub>2</sub> gets a value to be stored underground.

But it's a very logical and important point to make.

Senator PORTMAN. It would seem to be. What are the best geological formations for sequestration currently? What parts of the country are they?

Mr. KLARA. The good news is we've done a lot of study on options for storage.

Senator PORTMAN. You've got regional partnerships?

Mr. KLARA. Yes, absolutely.

Senator PORTMAN. You've got, what, 18 going around the country. So you've got some experience now.

Mr. KLARA. Yes. In fact we're already on our third version of a national atlas for the United States and Canada, nothing like it anywhere in the world. The bottom line is depending on the projection of how much reduction CCS would have to accommodate.

If that reduction is pretty large, what tends to happen is you really have to have the final backstop in these saline formations. EOR could play a key role. But when you're talking billions of tons potentially that's just a lot of volume to be dealing with.

So these saline aquifers—salt water, undrinkable—these are the real prime targets for the ultimate storage opportunity relative to CCS. Just to show you why CCS and sequestration tends to get a lot of hoopla that it does, the magnitude of these storage formations are huge even though the emissions are huge.

So for example, with our estimates so far, we found that the storage opportunities are widespread under at least 43 States. We've also found that they're huge, especially relative to the saline formations. That if you would look at the U.S. emissions in a given year, we have hundreds to thousands of years of capacity to store all those emissions.

So again, another reason why sequestration tends to be such an attractive option people don't want to get away from because it has that ability to store these huge, huge volumes, if needed.

Senator PORTMAN. Those of us, including Senator Manchin and myself, who are interested in this technology and want to move it forward. We like the fact that there's some hoopla, as you said, as-



sociated with it. Hope that the department and the industry, frankly and others in academia continue to focus on this.

It seems to me we're close to the technology that's commercial able on the capture side which seems to me is your biggest scientific challenge. Then on the sequestration side obviously there's a lot of issues including political issues that aren't science based. But we are committed to working with you on that and hope that again, after this hearing and others, that you're getting the message that there are lots of folks who believe that this hoopla is justified and that this is a way for us to make great gains using the coal resources that we have here in this country.

Thank you.

Mr. KLARA. Thank you.

Senator PORTMAN. Thank you all.

The CHAIRMAN. Senator Shaheen.

Senator SHAHEEN. Thank you, Mr. Chairman. Thank you all for being here this morning. I'm not sure exactly who to direct this question to because I was not here for all of the—all of your testimony. I apologize for that. So I'll just throw this out and see who responds.

Does S.669 address the most serious barriers that companies who are doing carbon capture and sequestration will face? If we pass this is, is this going to open the opportunities for companies to actually move forward in a way that will make this technology commercially viable? I'm particularly interested in this because we have a company in New Hampshire called Powerspan, that is—actually has their technology being tested in Ohio at First Energy, that First Energy utility is doing.

They believe their technology is very competitive in terms of cost with any of the other technologies that are out there. So if we were to pass this does this provide real opportunities for companies like Powerspan to move forward? Who would like to answer that?

There's no penalty. You can just step right up.

Ms. GREENBERG. Senator, I'll speak to a portion of that.

Senator SHAHEEN. OK.

Ms. GREENBERG. From the project perspective we spend a lot of time talking to a variety of stakeholders about issues related to carbon capture and storage. So I think from the perspective of companies being able to manage the real and perceived risks that they face from the public and various other stakeholders that this bill would go a long way toward addressing the liability issues which is one of the key issues that's brought up repeatedly from those stakeholders.

Senator SHAHEEN. Anybody else want to add? Yes?

Ms. TRABUCCHI. Yes, I'll actually follow on what Sallie just said. I think that one of the significant elements of the bill is that it sends a positive signal to the capital markets that there's perceived value in carbon capture and storage. That there should be a public/private sharing of the risks associated with that and the rewards associated with that.

I think that again, if there's a public policy goal that CCS can satisfy then what this bill does is it provides that necessary signal to say investment in this, these projects, these 10 projects, is warranted. Because at some point in the future that investment will

pay off either in a public policy reward and/or in financial rewards. I think that the indemnification provisions, the marriage that's been created by this bill with performance standards, the timing of when the liability relief happens coupled with dollar values and limits of liability, I think it's a nice coupling. I think it sends a positive signal.

Mr. WATSON. Senator, a bit more simplistic answer, but I don't think I'll be allowed back in the office if I don't make this point. The primary barrier to commercialization of CCS is the lack of a price on carbon. So we can make progress with bills like this but beyond applications like EOR or maybe you can get closer to it and have it be economical. Ultimately you're going to need a policy that creates a market for CCS.

Senator SHAHEEN. Thank you. I appreciate your making that point.

There was some discussion earlier about China. Is there—has there been any thought given to the idea of trying to set up a real cooperative effort with China? I mean, obviously, they stand to benefit significantly and they're working hard on this technology as well.

So has there been any thought given to our setting up a real formal working effort to try and see if we combine all of our scientists whether we could come up with a commercially viable technology faster?

Ms. GREENBERG. Senator, that's an excellent question. I would like to say that those efforts are already underway at a significant level both through the U.S. State Department, U.S. Department of Energy. We have hosted several delegations of Chinese scientists at the Illinois State Geological Survey to share with them the knowledge that we're getting first hand through our experiences.

The Director of our program, Dr. Robert Finley, has been to China as well. So there are very strong, individual, scientific partnerships and collaborations in place. I believe DOE just funded an international collaboration which is through Lawrence Berkley and the University of West Virginia and Tsinghua University in China.

So there really is actually quite, on the technical side, quite a lot of activity.

Senator SHAHEEN. Thank you. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Hoeven.

Senator HOEVEN. Thank you, Mr. Chairman.

It seems to me that the 2 big issues in getting the technology to move forward for carbon capture and sequestration are cost and liability. This legislation really goes to the liability aspect. I and our State of North Dakota, we've actually put a legal and regulatory regime in place that addresses the liability aspects. It's modeled after the Interstate Oil and Gas Compact Commission model legislation which some of you may be familiar with.

So it does appear to me that this legislation makes a very good attempt to deal with the liability aspect. I think that would be very helpful. Following this—and I hope I don't—I'm going to take a stab at your name. I know I'm going to get it wrong, Trabucchi, mentioned I think getting ten projects going would be phenomenally helpful.

Ms. TRABUCCHI. I'll take it.

Senator HOEVEN. Nobody wants to be first. Everybody wants to be second or third. Wants this commercially viable hence going to the question that I'd like each of you to address for a minute.

Mr. Watson got at it in a way. But not the way that I think we need to do it. The concept of mandating something I think is problematic particularly with our financial constraints that we have in the Federal Government today.

We have got to find a way to address the cost aspect where we use the CO<sub>2</sub> in a productive way. Hence, you know, tertiary oil recovery or maybe some type of coal to liquids conversion where you've got to, you know, an easier ability to capture that CO<sub>2</sub> in the process, but if you would address that cost driver. How do we put this CO<sub>2</sub> to use in a way that justifies a cost that will enable us to move this forward verses a mandate?

Mr. Watson, you could sure weigh in on this one too. Maybe you even want to start. But I'm looking for ideas on how we use it so that we can handle that cost aspect of moving this forward.

Mr. WATSON. Thank you, Senator. I think costs coming down is a function of experience and a function of the market. My point was that until we have a kind of policy in place that creates a market for CCS we're just not going to have the level of experience with it and the kind of deployment and economies of scale that will ultimately bring those costs down.

Senator HOEVEN. I don't mean to interrupt. But I mean revenue, revenue generation. The cost will come down as the technology gets better. It always does.

But some revenue aspect that helps us make this commercially viable.

Mr. WATSON. The EOR application seemed to be the most immediate one that could provide some source of revenue.

Senator HOEVEN. Right. Somebody well we're 10 years away. We've been 10 years away for the last 10 years.

We're constantly working to try to get more enhanced oil. We do that in our State. I mean, based on electric puts a down hold on the waiver and fields get paid for it.

But we want to do more with conventional coal fired plants. We can't seem to find somebody to take the CO<sub>2</sub>. Either it's not concentrated enough. It's too expensive, all these kinds of things.

We want to try to get coal to liquids going. Would that help pay for it?

Mr. WATSON. There are other smaller applications like the food services industries and others. Mr. Chairman, I'm reasonably certain you're not looking to re-litigate climate policy here right now. But you know, one of the values of the structures that were being considered was that it did create a value for that CO<sub>2</sub>.

Without a policy like that, absent these other applications, you really don't have one.

Senator HOEVEN. Other uses. Anybody? Obviously enhanced oil recovery. What else?

Where do we use the CO<sub>2</sub>? How do we get it in a useable form that generates revenue that helps bring this cost equation together?

Go ahead. Anybody? Any ideas? Any thoughts?

Ms. TRABUCCHI. I don't have the technical background to answer that specific question. But what I can say is I understand where you're coming from which is the financial and capital markets are looking for value proposition. Fundamentally it's revenue minus costs equals profit. If you can't generate a positive margin there has to—just purely on the function of price and cost, then there has to be some other proposition that fosters the need for the product, the technology, whatever it may be.

So, you know, I hear where you're coming from. I don't personally have the expertise to tell you what other technologies might be in use. But what I can say is your capital markets and your financial markets are very interested in this very same question.

If that's answered you're going to have more investment sooner.

Senator HOEVEN. Absolutely. So Mr. Klara, Ms. Greenberg in the lab and in your brainstorming sessions, what are we going to do with this CO<sub>2</sub> that's going to generate some revenue for us?

Mr. KLARA. The key obviously and you've addressed it, is that we have to come up with technologies that reduce the cost of the capture. I mean, at the end of the day it's the cost signal that's going to dictate, even if it's used for EOR.

Just to give you some dynamics. EOR, a lot of those agreements are business confidential. But generally speaking you can say in the neighborhood of \$20 a ton would be what you might purchase CO<sub>2</sub> for, for EOR.

Right now with the best technologies we have it will cost you \$60 a ton or more. But we are looking at sets of technologies that we believe can drive those costs down by two-thirds. So we do believe they're successful in the next 10 years that will start driving those, the cost of capture down.

Certainly at least with regard to EOR that the price signal might start to approach a price signal that might all of sudden it does open the flood gates for those opportunities which then just lets the technology base start rolling out.

Ms. GREENBERG. Senator, if I could just add 2 things that you touched on in your question that are also important to this. That is the purity of CO<sub>2</sub>. So technologies that give you less volatiles and added elements are important. Then also transportation and infrastructure that will get anthropogenic CO<sub>2</sub> from the locations where it is being produced to the places where you're going to be doing enhanced oil recovery.

Senator HOEVEN. Mr. Chairman, with your indulgence?

Exactly. Again, that goes to the cost equation. You have to have a pipeline to get it to the oil field typically or to the wells in the field. You have to have certain maturity on the wells. You have to have certain density of the wells. You have to have a certain concentration of the CO<sub>2</sub>.

All those things are vital to make it, you know, a commercially viable proposition. What I'm picking up from you and maybe Mr. Klara, I guess, you got there, is we really haven't come out with something other than enhanced oil recovery. We've got to drive the cost equation down further to make that commercially viable.

That's where you see the situation today.

Mr. KLARA. We do have a small portfolio looking at CO<sub>2</sub> reuse where you could convert the CO<sub>2</sub> to aggregate plastics, anything

that has carbon in it. Again, right now the state of that research is that those opportunities right now are much more expensive than getting those materials off the market today. They are looking at novel chemistry approaches etcetera to try to drive that cost down.

So those are other potential markets. But when you start looking at the magnitude of the CO<sub>2</sub>, those markets typically don't have enough capacity, even if we do drive those costs down, to make a big dent in emissions. But what they could do is, again, promote the idea of CO<sub>2</sub> capture and promote the idea of there are some opportunities to use this CO<sub>2</sub> in a value added way.

Senator HOEVEN. Thank you.

The CHAIRMAN. Let me just follow up on the point that you made, Ms. Greenberg, about transportation and the need there. At the current time there is no Federal agency with authority to site CO<sub>2</sub> pipelines. Should we change that and give FERC that authority?

Ms. GREENBERG. I think that if enhanced oil recovery at the use of anthropogenic CO<sub>2</sub> is a goal in, as Senator Hoeven was saying, in doing something with our CO<sub>2</sub>. Then anything that the Federal Government can do to facilitate the siting and building of a pipeline infrastructure is certainly advantageous.

The CHAIRMAN. Good. Let me ask, Mr. Klara. You had said about \$20 a ton is the price that people are—that companies are paying for CO<sub>2</sub> for enhanced oil recovery. Is that what I understood you to say?

Mr. KLARA. Yes, and generally speaking you're like \$10 to \$30 per ton. So I just used \$20 as a—

The CHAIRMAN. Right. Because yesterday, one of our witnesses said that. I asked him what the price of CO<sub>2</sub> was in the Permian Basin. He was saying that it had been about a dollar an MCF, but that he'd seen a recent contract where they had agreed to pay \$2 per MCF.

Is that—I'm not quick enough to tell you how you convert MCFs to tons. Can you tell me whether that is pretty much what you said or not?

Mr. KLARA. Yes. That should be in the ballpark. Yes.

The CHAIRMAN. OK.

Mr. KLARA. I can't remember the conversion off the top of my head. But yes, those are close numbers. But a point I want to make is that CO<sub>2</sub> pricing is complicated. It's often related to the oil prices.

So how these agreements get made have some complexity to it. So if the oil price goes up high or goes down, that also impacts, you know, what the price is that somebody pays for the CO<sub>2</sub>. So it's an ever changing, you know, with the oil prices, well, it's ever changing what it is.

But a good number and you kind of got to think in tons, but you know, \$10 to \$30 per ton is a nice range of probably where most, if not all, of the price for CO<sub>2</sub> for EOR kind of resides.

The CHAIRMAN. OK.

Senator Manchin.

Senator MANCHIN. Thank you, sir.

I think just in general I'm speaking that what does the cost of carbon capture add to the price of energy as far as the house? Any of you all can talk about that. What is done in the legislation that we can continue to pursue? If this is passed on what would that be to the consumer? What does it mean to the manufacturers?

I know that in a realm of coal fired electricity being what drives most of our industry right now. Manufacturing because of its competitive cost, it has gone up dramatically and it seems to keep going up dramatically. Can you put a price on that?

Mr. KLARA. If we were to look at off the shelf technologies today for CO<sub>2</sub> capture and transport and storage, but capture by far is 80 percent of the cost for that.

Senator MANCHIN. Are you talking about even retrofitting existing plants?

Mr. KLARA. Yes.

Senator MANCHIN. Such as a mountaineer plant.

Mr. KLARA. So if you were to look at a retrofit opportunity, it could add as much as 80 percent to the cost of electricity adding CCS. If you were to look at a new technology like gasification, and the reason why it gets so much interest is that it's more conducive, you'd add maybe about 35 percent to the cost of electricity.

If you look, take a snapshot forward on a road map saying what might happen in 10 years if the research portfolio is successful? Our desires would be we drive that cost down to maybe a 20 percent increase in cost of electricity and a 10-percent increase in cost of electricity if all is successful. But there's still going to be a cost increase.

Senator MANCHIN. We understand.

Here's my concern. We're competing with all these manufacturing, these Third World developing countries, whether it be China coming on so strong taking most of our jobs, if you will. You have India. You have all the different.

They're dealing with a much lower cost base on their energy than what we are as I understand. We used to be in a 4 to 6 cent range as far as commercial on a kilowatt hour.

Mr. KLARA. Right.

Senator MANCHIN. You start driving that up 20, 40, 60, 80 percent expeditiously before. You just give them a greater competitive advantage. That doesn't make sense to us as Americans why we would lose more jobs because of our high cost of manufacturing when we don't have the proven technology, I think, is the point that I'm making. Why the money should be put on the technology or on the research to find the technology.

Do you see us putting a very disadvantaged competitive situation here with China, India?

Mr. KLARA. I'm a technologist. But certainly it's a worldwide issue and just to go to your point. Now, how that gets addressed is way beyond my—

Senator MANCHIN. Do any of you all want to speak to that? I know you knowing what your cost is. At West Virginia we pulled out of the FutureGen because of liability at the end result. We were on the forward down to the wire and we supported all noise at the back. They were willing to take the whole liability.

You don't have any comment on that one do you? I don't blame you. Any of you all have a comment on this competitive advantage or disadvantages that we're putting ourselves in by moving before we have technology?

I think what I'm saying we're moving policy before technology is readily available and that we can put a cost to it, to the point that we can still be competitive worldwide.

Mr. Watson.

Mr. WATSON. Senator, well I'm not sure I follow you. This bill wouldn't mandate anyone to use CCS.

Senator MANCHIN. But the reality is is the Federal Government is not giving any permits. We're not expanding. You can't build anything. You can't do a thing.

They've got you tied up with EPA and everything else because unless it has CCS attributed to it, you're not going to get a permit.

Mr. WATSON. I'm not aware that that's the case, Senator. My understanding is that power plants are being permitted and built.

Senator MANCHIN. Oh, please give me the list where ever you found one?

Mr. WATSON. I'd be happy to get that for you.

Senator MANCHIN. You're saying new coal fired plants without CCS is being built?

Mr. WATSON. Yes, sir. I'd be happy to get you something.

[The information referred to follows:]

Power Plant	Owner	State	Operating Status	Current Generating Capacity
Dry Fork Station	Multiple	WY	Under Construction	385.00
Edwardsport IGCC	Duke Energy Indiana Inc.	IN	Under Construction	618.00
Formosa Point Comfort	Formosa Plastics Corp	TX	Under Construction	286.20
Goodland Energy Center	Goodland Energy Center LLC	KS	Under Construction	25.00
John W. Turk, Jr. UPC	Multiple	AR	Under Construction	600.00
Longview Power	Multiple	WV	Under Construction	700.00
Plant Ratcliffe IGCC (David)	Mississippi Power Co.	MS	Under Construction	596.10
Prairie State Energy Campus	Multiple	IL	Under Construction	1,600.00
Sandy Creek	Multiple	TX	Under Construction	900.00
Spiritwood Energy Cogen Plant	Great River Energy	ND	Under Construction	99.00
Two Elk One	North American Power Group	WY	Under Construction	290.00
Virginia City Hybrid Energy Center	Virginia Electric & Power Co.	VA	Under Construction	585.00

Senator MANCHIN. Please, please, please.

Ms. Greenberg, do you know of any?

Ms. GREENBERG. Not off the top of my head.

Senator MANCHIN. I don't either. I don't either.

Mr. Klara, how about you? Do you know any new power plants being built, coal fired power plants?

Mr. KLARA. I'd have to look into that.

Senator MANCHIN. OK.

The CHAIRMAN. Thank you all very much. Think it's been a useful hearing. Appreciate your excellent testimony.

That will conclude our hearing.

[Whereupon, at 10:12 a.m., the hearing was adjourned.]

[The following statement was received for the record.]

PREPARED STATEMENT OF BEN LUBBON, MANAGING DIRECTOR, JUDE BENEDICT & ASSOCIATES, IN BEHALF OF ORIGIN OIL AND THE ALGAL BIOMASS INDUSTRY

Thank you Chairman Bingaman, Ranking Member Barrasso, and members of the Committee; I appreciate the opportunity to submit public comment for the record to promote algae-to-oil technology's capability and its rapid development of carbon capture and storage (CCS).

After listening to the hearing and reading written testimony; one item was apparent; algae-to-oil technology's capability to capture and sequester carbon was unfortunately not mentioned. Yet, this was not a fault of any one individual; the technology is advancing in great strides ahead of communicating these efforts to Capitol Hill. Fortunately, due to the avenue of public comment; I am able to inform you of the attributes of this promising technology.

#### S. 757 APPLIES TO ALGAE TECHNOLOGY

Algae carbon bio-capture technology is a post-combustion process. It involves no geo-sequestration; a pre-combustion process injecting CO<sub>2</sub> into the ground. Therefore, S. 699 does not apply to Algae Technology.

#### S. 757 IS A GREAT START

First, the bill needs a short title: the Direct Air Carbon Capture Act would suffice.

S. 757 has two provisions: (1) a direct air carbon dioxide capture prize and (2) the initiation of a nine member Carbon Capture Task Force appointed by the administration.

However, "algae carbon bio-capture" is at a pilot-to-commercial stage at three coal-fired power plants in Australia. In the Land Down Under, they are advancing free enterprise deploying US technology. In the Land of the Manhattan Project and putting Men on the Moon, a prize short sells our proprietary knowledge. We as a Nation are better than this. Amending this bill should include financial and legislative support.

#### ALGAE-TO-OIL DIRECT AIR CARBON CAPTURE IS SAFER AND PRODUCES MULTIPLE REVENUE STREAMS

Geo-sequestration: Injecting anything into the ground and not thinking it will end up in the water table defies common sense. Environmental groups, with just cause; will tie up geo-sequestration projects in the environmental study and review process. And then, there will be the challenges in the Courts.

Algae Carbon Bio-Capture: Direct-air carbon capture is a multiple proactive "win-win-win!"

The post-combustion process sucks CO<sub>2</sub> directly from the flue stack. Algae growth thrives in closed-loop industrial bolt-on bio-reactors and reclaims dirty polluted brackish water. A multitude of products from drop-in biofuels, pharmaceuticals, nutraceuticals, oil-based chemicals, plastics, human food and supplements, animal feed and fertilizer; are just a few of algae's revenue producing drivers. Research has proven algae cures blindness in mice; cures for cancer are soon to follow. The final kicker, the remaining biomass left in the closed-loop system, is burned as "biochar" which sequesters the CO<sub>2</sub> and is used as a soil supplement.

Algae Technology is also a major job creator. With wind, solar and geo-sequestration technologies; once a project is constructed, there are few jobs to maintain the



facility. Algae technology, on the other hand, is labor intensive throughout construction, maintenance and production phases of the co-located power plant algae refinery. Jobs downstream from supply distribution networks will be exponential.

#### ALGAE TECHNOLOGY'S NEGATIVE

Skeptics and cynics claim if algae technology is so great; then why isn't it a thriving free market enterprise? Yet, this rings true for all promising technology to overcome throughout History. Fossil fuels still get subsidies; the algae industry just wishes for an even playing field. Furthermore; legislative government support is far more imperative than federal financial aide. Long-term legislative federal stability is what the investment community demands to minimize risk before they will support the free-market.

The pre-combustion geo-sequestration process is also an unproven technology with challenges to overcome.

#### CONCLUSION

Previous CCS legislation includes billions of dollars to be allocated. "Bio-capture" and geo-sequestration are both viable choices and deserve parity. Both bills deserve further review at the committee level before going to a floor vote. There are several regions worthy of geo-sequestration; and, there are some that are questionable. There are no silver bullets in our pursuit for energy independence; there's just a lot of silver buckshot. We must promote them all in a full climate capitalism approach rather than argue about the ideologies of climate change. Before any decisions are made per energy policy; our government leaders need to hear more from its entrepreneurial energy leaders who are taking monumental risks in the name of energy independence and national security.

Thank you for your consideration.



## APPENDIX

### RESPONSES TO ADDITIONAL QUESTIONS

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RESPONSES OF SALLIE E. GREENBERG TO QUESTIONS FROM SENATOR BINGAMAN

*Question 1.* In the project that you have been involved with in Illinois that partners with Archer-Daniel Midland, have you encountered any unexpected events or unknown risks that your project team did not expect to? Is there anything that has impacted your views of the risks associated with geologic CCS?

Answer. Three categories of unexpected events or risks have occurred during the course of the Illinois Basin—Decatur Project (IBDP) in Decatur, Illinois: 1) Geologic/Operational, 2) Material Compliance, and 3) Regulatory Response.

Geologic/Operational events occurred during the drilling the injection well at IBDP when we encountered a carbonate rock unit with dissolution features, which caused a loss of circulation of drilling mud. Mitigating this “lost circulation zone” resulted in the loss of time and increase in cost to drill the well. Risks such as this are common when little direct geologic information, such as stratigraphic well logs and samples, is available. Risk mitigation for the second, deep monitoring well, benefitted from the knowledge of the lost circulation zone and a mitigation strategy was put into to place, such that minimal time was lost and limited cost incurred. Events such as these speak to the necessity of Applicants under S.699 needing to have substantial geologic data available when applying for liability assurance from the Secretary.

Material Compliance with Underground Injection Control (UIC) Class VI regulations may prove to be difficult. An example from the IBDP is in our preemptive decision to use chrome steel in the lower 2,000’ of the injection interval. This decision was made in anticipation of the Class VI regulations (which were in the rulemaking process at the time) that would require the use of carbon dioxide (CO<sub>2</sub>) resistant well construction materials. We were initially unable to find chrome steel casing for the injection well and ultimately found the material in a yard in Aberdeen, Scotland. The material was shipped to our location, inspected, and approved for use. This material shortage potential may result in operators using materials that do not meet the UIC regulations and will have to be closely monitored.

Lastly, while not an environmental or operational risk, but a significant risk for researchers and future commercial investors, is the lack of knowledge of dense-phase CO<sub>2</sub> and oil field (or deep subsurface) technologies applicable to carbon capture and storage (CCS) on the part of regulators. To date, our permitting process has extended over 3+ years and continues to be extended as the Class VI regulations are put into place. That lack of knowledge has to be remedied by targeted training, otherwise wider deployment beyond the research phases and the long-term monitoring responsibility of the Environmental Protection Agency will be hampered.

*Question 2.* I am aware that you have worked very deeply in the areas of public outreach, awareness, and acceptance issues of geologic CCS. Based on your research—what have been the biggest areas of concern for public stakeholders? Do you have any recommendations for project developers as they undertake these types of large-scale CCS projects?

Answer. The most commonly expressed concerns we encounter relate to two areas: 1) subsurface misconceptions, and 2) surface technical and nontechnical issues.

Public concerns about the concept of CCS stem from misconceptions about the nature of the subsurface. Members of the general public often perceive that CO<sub>2</sub> will be stored in large underground caverns and lack knowledge of the actual process of storage, which takes place in small rock pore spaces. This perception is further compounded by the perceived uncertainty of earthquake impacts on stored CO<sub>2</sub>. In fact, the most frequently asked questions we encounter are, “What will happen to stored CO<sub>2</sub> in the event of an earthquake?” and “Will CO<sub>2</sub> injection cause earthquakes?” Additional subsurface concerns focus on the displacement of brine during CO<sub>2</sub> injection and the perception that brine migration will result in contamination

of fresh water or migration to the surface. With careful explanation, physical models, and demonstration tools, these concerns can be addressed and alleviated. Future project developers should avail themselves of CCS communication experts and utilize best practices manuals to develop public engagement strategies. Engaging and informing the public will be essential to commercial deployment.

Surface technical and nontechnical issues are also of great concern to the public, especially landowners in close proximity to CCS projects. We have experienced landowners who after discussions express no further concern with the subsurface storage concept of CCS, but rather are concerned with what bringing a CO<sub>2</sub> pipeline through their driveway will do to their property values and/or ability to use the area. Issues such as the perceived decrease in property value due to stored CO<sub>2</sub>, liability over stored CO<sub>2</sub> after the close of a project, and distrust of government to adequately regulate project developers and protect citizens are often expressed. Project developers will need to be held to the highest performance standards in order to warrant the trust of the public. In addition, liability funds or other financial mechanisms will need to be adequately managed, regulators properly trained, and commercial projects successfully operated for long periods of time in order to minimize public concerns.

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#### RESPONSES OF CHIARA TRABUCCHI TO QUESTIONS FROM SENATOR BINGAMAN

*Question 1.* Can you speak briefly on what you think the real vs. perceived risks for a given geologic CCS project are?

Answer. There are a number of studies which have attempted to identify and assess the range of risks potentially related to CCS during the project lifecycle, and which give rise to the need for financial responsibility (see, for example, Donlan and Trabucchi, 2010; Trabucchi et al., 2009; Trabucchi and Patton, 2008; Bacanskas et al., 2009; WRI, 2008; DOE, 2007; OSPA, 2007).

Briefly stated, CCS may adversely impact human health and the environment through a variety of pathways (see, IPCC, 2005 for a broad based discussion of these impacts from the operational phase of a CO<sub>2</sub> capture unit, and Bacanskas et al., 2009 for how adverse impacts could impact human and ecological receptors during the lifecycle of a CO<sub>2</sub> storage operation). Specifically, CCS risks include, but are not limited to: (1) groundwater contamination; (2) surface/subsurface trespass, (3) asset infringement, (4) bodily injury; (5) property damage; (6) ecological damage; and/or (7) business interruption.

Delimiting factors that will influence the degree of injury at a particular CCS project include site-specific geology and geochemistry, proximity to population centers, infringement of valuable (sub)surface resources, increasingly scarce sources of potable surface and ground water, and protected or sensitive (endangered) habitats. The nature and degree to which one or more of these factors are applicable to a particular CCS project will shape its risk profile and create the potential for financial consequences in the form of corrective action (e.g., mitigation, remediation expenses) and/or compensatory damages. Establishing permitting and performance-based standards to ensure sound siting, design, operation and management of the CCS project will contribute to risk mitigation and limit the degree to which harm or injury, and attendant compensatory damages arise.

*Question 2.* Where do you think the hardest economic step or gap is for project developers? CCS project financiers? What can project developers do to reduce the risks perceived by project financiers? In other words, what is the financial community the most concerned with for CCS projects?

Answer. When considering whether or not to invest in a project, developers and financiers will assess the degree to which the project will realize a net positive return on investment. A generally accepted practice in investment valuation is conducting a discounted cash flow analysis. This type of analysis considers the present value of the project's forecasted cash flows, net of the project's initial investment. If the net present value (NPV) is greater than zero, then the project is accepted. If the NPV is less than zero, then the project is rejected. Essentially, developers and financiers are seeking value creation which will result in positive cash flows, and therefore positive return on investment.

Project financing that relies on this type of analysis necessitates the ability to identify and value the stream of a project's cash flows. To effectively assess the project's NPV, a degree of certainty is required with respect to: (1) the cash flows generated by the project; (2) the cost of investing in the project; and (3) the terminal value of the assets comprising the project, i.e., either salvage, or sale. Projects with positive cash flows, minimal costs, and high terminal value represent strong investment potential to project financiers.

In my view, the limited analytic evaluation of the range of potential impacts, and corresponding financial consequences attributable to individual CCS projects, has hindered project financing. On a project-specific basis, answers are needed to the questions: "What are the dollar amounts that need to be managed?" "Under what set of circumstances, will amounts present?" "Across what time frame will these dollars be needed?" I believe that focus on anecdotal references with respect to possible financial consequences arising from CCS projects has contributed to unreasonable expectations and misunderstandings with respect to the amount and timing of funds necessary for the responsible deployment of CCS. As a result, the developer and project financier's ability to accurately forecast key variables in the project's NPV, i.e., the 'cost of investing in the project' and 'the terminal value of the project's assets', is limited. As long as financiers are unable to reduce a CCS project to its net present value, they are unlikely to place their investment capital behind the technology.

In addition, the public debate on 'liability' as it relates to the long-term stewardship of CCS projects, i.e., who should bear financial responsibility for paying claimants when damages occur, has clouded the ability of project financiers to accurately assign a risk premium to their calculus of whether CCS represents a viable business venture. In my view, S. 699 is a measurable step forward in offering a measure of certainty with respect to this issue.

*Question 3.* You state in your testimony on page 5 that the bill should include a requirement for the explicit evaluation of potential human health and environmental impacts from a financial perspective. Would a requirement for a financial risk analysis on a per applicant/project basis fulfill this need?

Answer. Yes, as long as the requirement for a financial risk analysis explicitly includes consideration of the financial consequences arising from possible human health and/or environmental impacts on a per applicant/project basis.

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#### RESPONSES OF SCOTT KLARA TO QUESTIONS FROM SENATOR BINGAMAN

*Question 1.* While you state in your testimony that the official DOE position is that the bills are still under review, is it your opinion that a program such as that S. 699 is a program that your office could oversee and facilitate? In other words,

do you have workforce and technical capabilities to administer the indemnity program laid out in the bill?

Answer. The Administration is still reviewing S. 699 and S. 757 and does not have a position on either bill at this time. However, as part of the plan proposed by the Interagency Task Force on Carbon Capture and Storage:

“Efforts to improve long-term liability and stewardship frameworks should continue. By late 2011, EPA, DOE, Department of Justice (DOJ), DOI, and Treasury should further evaluate and provide recommendations to address long-term liability and stewardship in the context of existing and planned regulatory frameworks. Of the seven options identified by the Task Force, the following four approaches, or combinations thereof, should be considered: (1) reliance on the existing framework for long-term liability and stewardship; (2) adoption of substantive or procedural limitations on claims; (3) creation of an industry-financed trust fund to support long-term stewardship activities and compensate parties for various types and forms of losses or damages that occur after site closure; and (4) transfer of liability to the Federal government after site closure (with certain contingencies). Open-ended Federal indemnification should not be used to address long-term liabilities associated with CO<sub>2</sub> storage.”

*Question 2.* Are there currently projects in the CCS program that would be of the scale and caliber that would qualify for the program specified in S. 699?

Answer. The DOE has multiple CCS demonstrations projects underway (through the Clean Coal Power Initiative, FutureGen 2.0, and Industrial Carbon Capture and Storage) as well as a set of large-scale injection tests through the Regional Carbon Sequestration Partnerships (RCSPs) that would likely fit the project definition contained in the bill. However, the Administration is still reviewing S. 699 and S. 757 and does not have a position on either bill at this time.

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#### RESPONSES OF MATT WATSON TO QUESTIONS FROM SENATOR BINGAMAN

*Question 1.* EDF has worked very closely with the states in helping to develop the regulatory mechanisms for geologic CCS projects. Is there one state in particular that has most accurately quantified risk and liability for these projects that we could use as model or example for thinking about this federal legislation?

Answer. Although no state has created a fully adequate model, North Dakota and Texas each have experience to share that the Committee could find useful. Both states have examined these issues in the context of setting fees for trust funds and processing of permits.

*Question 2.* Have you encountered any CCS projects that have incurred liabilities (even at the pilot to demonstration scale)?

Answer. We are not aware of any CCS projects that have incurred liabilities.

*Question 3.* You mentioned the coal plants and siting at the hearing—to get specifically at the issue of coal plant siting—what are the requirements for new coal plant construction under BACT regulations? Can you provide a list of coal plants under siting and construction?

Answer. Senator Manchin raised the issue of coal plant permitting during the hearing. If I understood him correctly, his belief is that CCS is not a fully-developed, commercially-available technology and, yet, EPA regulations are requiring permit applicants for coal-fired generating units to employ CCS—and that permits were being denied because applicants weren’t planning to use CCS.

To our knowledge, there has been no case in which a permitting agency has denied an air permit for a coal-fired power plant on the grounds that the applicant failed to employ CCS as a control technology for greenhouse gas emissions.

Under the Clean Air Act’s Prevention of Significant Deterioration (PSD) Program (§§ 165-169), any major stationary source of air pollutants that is to be constructed or undergo a major modification must obtain a permit that includes an emissions limitation for each pollutant regulated under the Clean Air Act. The emissions limitation is based on a source-specific analysis, conducted by the state or federal permitting authority, to identify the Best Available Control Technology (BACT) for that source. In Step 1 of a BACT analysis, all available pollution control options are identified. In Step 2, technically infeasible options are eliminated. In Step 3, the list of available and technically feasible controls are ranked in terms of environmental effectiveness. In Step 4, economic, energy, and environmental impacts are considered in determining whether each control option is “achievable.” After identifying the most environmentally effective control option that is achievable, the permitting authority then specifies an emissions limitation for the source that reflects the max-

imum degree of reduction achievable for the pollutant considering economic, energy and environmental impacts. Although a source is required to meet the emissions limitation, it is not required to install the control technology used in the BACT analysis to derive the emission limit.

After conducting extensive stakeholder outreach, the Environmental Protection Agency released guidance for state permitting authorities to use in identifying BACT for sources requiring PSD permits for their greenhouse gas emissions. In that guidance, EPA specifically discussed the potential for CCS to be identified as BACT by a permitting authority:

[A]lthough CCS is not in widespread use at this time, EPA generally considers CCS to be an “available” add-on pollution control technology for facilities emitting CO<sub>2</sub> in large amounts and industrial facilities with high-purity CO<sub>2</sub> streams. Assuming CCS has been included in Step 1 of the top-down BACT process for such sources, it now must be evaluated for technical feasibility in Step 2. CCS is composed of three main components: CO<sub>2</sub> capture and/or compression, transport, and storage. CCS may be eliminated from a BACT analysis in Step 2 if it can be shown that there are significant differences pertinent to the successful operation for each of these three main components from what has already been applied to a differing source type. For example, the temperature, pressure, pollutant concentration, or volume of the gas stream to be controlled, may differ so significantly from previous applications that it is uncertain the control device will work in the situation currently undergoing review. Furthermore, CCS may be eliminated from a BACT analysis in Step 2 if the three components working together are deemed technically infeasible for the proposed source, taking into account the integration of the CCS components with the base facility and site-specific considerations (e.g., space for CO<sub>2</sub> capture equipment at an existing facility, right-of-ways to build a pipeline or access to an existing pipeline, access to suitable geologic reservoirs for sequestration, or other storage options).

While CCS is a promising technology, EPA does not believe that at this time CCS will be a technically feasible BACT option in certain cases. As noted above, to establish that an option is technically infeasible, the permitting record should show that an available control option has neither been demonstrated in practice nor is available and applicable to the source type under review. EPA recognizes the significant logistical hurdles that the installation and operation of a CCS system presents and that sets it apart from other add-on controls that are typically used to reduce emissions of other regulated pollutants and already have an existing reasonably accessible infrastructure in place to address waste disposal and other offsite needs. Logistical hurdles for CCS may include obtaining contracts for offsite land acquisition (including the availability of land), the need for funding (including, for example, government subsidies), timing of available transportation infrastructure, and developing a site for secure long term storage. Not every source has the resources to overcome the offsite logistical barriers necessary to apply CCS technology to its operations, and smaller sources will likely be more constrained in this regard. Based on these considerations, a permitting authority may conclude that CCS is not applicable to a particular source, and consequently not technically feasible, even if the type of equipment needed to accomplish the compression, capture, and storage of GHGs are determined to be generally available from commercial vendors.<sup>1</sup>

In discussing consideration of CCS under Step 4 of the BACT process, EPA noted that:

[A]t present CCS is an expensive technology, largely because of the costs associated with CO<sub>2</sub> capture and compression, and these costs will generally make the price of electricity from power plants with CCS uncompetitive compared to electricity from plants with other GHG controls. Even if not eliminated in Step 2 of the BACT analysis, on the basis of the current costs of CCS, we expect that CCS will often be eliminated from consideration in Step 4 of the BACT analysis, even in some cases where underground storage of the captured CO<sub>2</sub> near the power plant is feasible. However, there may be cases at present where the economics of CCS are more

<sup>1</sup> Environmental Protection Agency, “PSD and Title V Permitting Guidance for Greenhouse Gases,” p. 35-36 (March 2011).

favorable (for example, where the captured CO<sub>2</sub> could be readily sold for enhanced oil recovery), making CCS a more viable option under Step 4. In addition, as a result of the ongoing research and development described in the Interagency Task Force Report noted above, CCS may become less costly and warrant greater consideration in Step 4 of the BACT analysis in the future.<sup>2</sup>

EPA's analysis of control options was primarily focused on power plant efficiency measures that could be put in place as a means to reduce the quantity of greenhouse gases emitted per unit of energy produced.<sup>3</sup>

While there have been several coal plant cancellations over the past two years, these cancellations have primarily been the product of reduced energy demand resulting from the increasing costs and financing difficulties, the economic downturn and low natural gas prices—not regulatory requirements relating to greenhouse gases. Further, the requirement to obtain an air permit for greenhouse gases under the Clean Air Act only recently took effect, becoming operative on January 2, 2011. And while natural gas power plants are increasingly considered a more financially attractive option for new fossil fuel-based generation, there are coal-fired projects pending in various stages of development. The SNL Financial power plant data base describes the twelve coal fired power plants listed below as under construction.

Power Plant	Owner	State	Operating Status	Current Generating Capacity
Dry Fork Station	Multiple	WY	Under Construction	385.00
Edwardsport IGCC	Duke Energy Indiana Inc.	IN	Under Construction	618.00
Formosa Point Comfort	Formosa Plastics Corp	TX	Under Construction	286.20
Goodland Energy Center	Goodland Energy Center LLC	KS	Under Construction	25.00
John W. Turk, Jr. UPC	Multiple	AR	Under Construction	600.00
Longview Power	Multiple	WV	Under Construction	700.00
Plant Ratcliffe IGCC (David)	Mississippi Power Co.	MS	Under Construction	596.10
Prairie State Energy Campus	Multiple	IL	Under Construction	1,600.00
Sandy Creek	Multiple	TX	Under Construction	900.00
Spiritwood Energy Cogen Plant	Great River Energy	ND	Under Construction	99.00
Two Elk One	North American Power Group	WY	Under Construction	290.00
Virginia City Hybrid Energy Center	Virginia Electric & Power Co.	VA	Under Construction	585.00

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<sup>2</sup>Id. at 42-43.

<sup>3</sup>Environmental Protection Agency, "Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from Coal-Fired Electric Generating Units," p. 26-35 (October 2010).